

Metallurgical & Chemical Engineering

Volume XII, Number 12

December 1914

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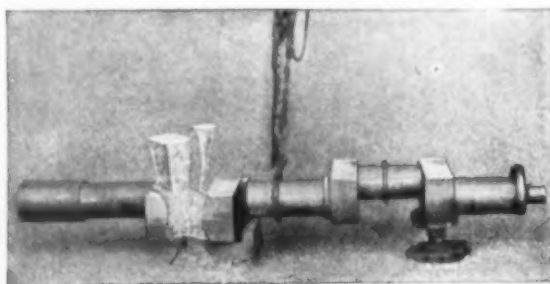
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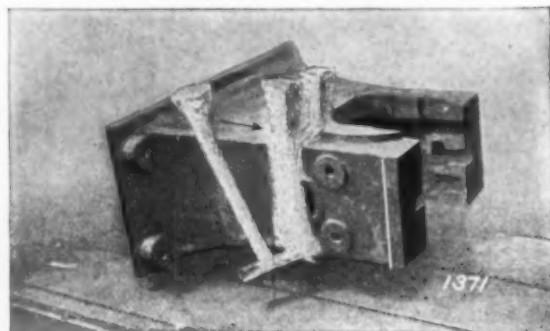
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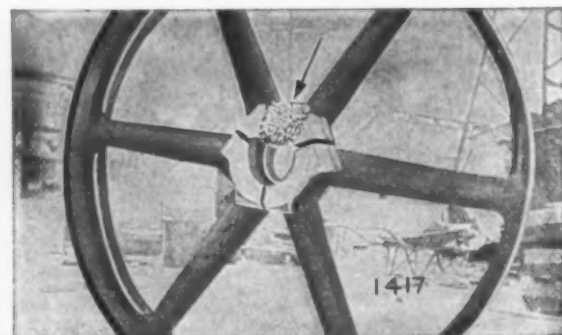
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Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII

NEW YORK, DECEMBER, 1914

No. 12

PUBLISHED MONTHLY BY THE McGraw Publishing Company, Inc.

JAMES H. MCGRAW, President.

Secretaryship vacant.

JOHN T. DEMOTT, Treasurer.

239 West 39th Street, New York.

TELEPHONE CALL, 4700 BRYANT.

CABLE ADDRESS, METCHEM, NEW YORK.

ROCKY MOUNTAIN OFFICE.....421 Boston Bldg., Denver, Colo.
PACIFIC COAST OFFICE.....502 Rialto Bldg., San Francisco, Cal.
CHICAGO OFFICE.....Old Colony Building
PHILADELPHIA OFFICE.....Real Estate Trust Building
LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, Ph.D., Editor.
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Yearly subscription price for United States, Mexico and
United States dependencies, \$2.00; for all other countries,
\$2.50. (European exchange, 10 shillings, 10 marks, 12.50
francs.)

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Entered as Second-Class Matter at the Post Office at New York,
N. Y., under the Act of Congress, March 3, 1879.

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Metallurgy in the Northwest

Montana is a wonderful mineral domain; Anaconda is a metallurgical center of the first magnitude. From it have emanated innovations in the treatment of copper ore that have commanded respect and admiration, and to it have gravitated many men with faith and hope in new schemes that loomed large as possibilities but sometimes failed of realization. Within its own organization has been maintained one of the best-equipped research departments in the country. Problems have been attacked with vigorous intelligence, and the results show what can be accomplished by an organization backed by brains, money and the progressive spirit of research.

The record of the past few years is an inspiration. Beginning with the attack on slime concentration, there was evolved the twenty-deck round table and a special application of Dorr thickeners to handle daily 2500 tons of practically 200-mesh slime contained in 26,000,000 gal. of pulp. Then came the leaching experiments on sand tailing, proved on a large scale in an 80-ton unit and followed by the erection of a 2500-ton plant. The cheap production of sulphuric acid ensued as a natural development of the leaching process; and as an abundance of this material can be produced, far in excess of the demand for leaching, it is reported that the manufacture of phosphate fertilizer will be undertaken to consume the excess. Flotation is now engaging the attention of the staff and tests are being made on Minerals Separation and Callow processes. Active work on the smelter-fume problem is affording interesting developments of the Cottrell electric precipitation process, one of which is the use of pipe-treaters up to 4 ft. in diameter. The successful evolution of this method of handling fume may result in abandoning the extensive flue system and the erection of a new stack that will surpass in dimensions all previous construction of this type.

So much for copper in Montana. In the adjoining state of Idaho there is evidence that metallurgy may cut a large figure in the Coeur d'Alene lead district, where ore-dressing has held full sway. The Bunker Hill & Sullivan company has been experimenting with dry chlorination, and the president of that concern recently declared that the anticipated success of the process would mean for the Coeur d'Alenes the production of metals instead of concentrates. We hope his vision may be realized. In this connection a word of caution may not be out of place. Coeur d'Alene operators are skilled in ore-dressing; but chemistry applied to ore treatment is a very different matter, and it will require a new group of men skilled in the art to bring success. The

great variety of effective work done at Anaconda is due to an organization of specialists; the same conditions must obtain in Idaho.

Passing the Buck

A paper on a technical subject was promised for a recent joint meeting of the New York sections of several scientific societies. It was duly passed upon, as commercially harmless, by the company with which the author was connected; but presentation was prohibited at the last moment by another company with patent working arrangements with the first one.

This reminds us of the permits which are given to war correspondents by one of the allied powers and regretfully countermanded by the others.

The By-product of a Chemical Reaction

The *Mining Magazine*, of London, comments on our editorial on the European war, but deals almost exclusively with matters which we neither said nor suggested nor hinted at. We leave the relevance and good taste of the comment of our London critic entirely to the judgment of our readers, who have our original remarks on record in our September issue for comparison of quotations and interpretation. We have no reason to modify in the least our opinions there expressed. We publish the *Mining Magazine's* comment in full as an illustration of the correctness and pertinence of our original sketch of the psychological situation:

"Our sympathy goes to Mr. E. F. Roeber, Ph.D., editor of *Metallurgical and Chemical Engineering*. We met him last at the American Institute dinner and meeting called to do honor to Dr. Friedrich Kolbeck, of the Freiberg Mining Academy, at New York, last May. The affair had a pronounced German flavor, from the chairman's German accent to Dr. Kolbeck's speech in German, but that was no blemish then; we were glad to be present and to participate in paying a deserved compliment to the worthy representative of the great German mining school. In the September issue of his periodical, Dr. Roeber concludes that "all Europeans have suddenly gone crazy." He speaks of "crowds and nations that act under the blind forces of Nature." The war, to our genial acquaintance at New York, is a "gigantic human reaction" in which "the most celebrated individualities do not seem to have much more freedom of will than the 'free' ions of the dissociation theory." This may be a delightful chemical simile, but to us it is flavored too much with that pestilent Prussian notion that war is a 'biological necessity,' that the breaking of a treaty is condoned by necessity, that atrocities are another part of warlike necessity, and so forth, to the end of the ensanguined chapter of mad militarism. No, Dr. Roeber, this will not do. The prevalence of such ideas among educated Germans, the acquiescence of university professors in the sinister writings of the Treitschke and Nietzsche school, and the lack of protest against the vaporings of the Potsdam War-Lord are among the causes of this great catastrophe. To us the preaching of organized murder in terms of culture is an abominable impertinence. Nay more, the violation of women, the hacking of young mothers' breasts, the murder of little children, the burning of helpless captives, the shooting of inoffensive peasants in the field may be acts of individual savagery for which the General Staff and the Kaiser are not responsible, but the sacking of Louvain and the destruction of Rheims cathedral, together with several other atrocities on a large scale, are the acts of high authority, for which no excuse has been, or can be, offered. In the face of such wanton barbarism, the chemical simile of 'necessity' is an insult to human intelligence."

Local Section Meetings

The tendency toward centralization of the activity of the national scientific and engineering societies is justified to a certain extent, but should never go so far as to detract from the great importance of the work of local sections. No legitimate expense for the conduct of the local sections should be considered too big. Local sections can accomplish in an informal way a great deal that cannot be done in a formal way nor with the necessarily cumbersome machinery of the national society.

We are glad to note the excellent work of the New York sections of the different chemical societies. Last winter the New York section of the American Electrochemical Society, under Mr. Addicks' chairmanship, did really important pioneer work in holding a series of very enjoyable and profitable joint meetings not only with the other chemical societies, but with the mining engineers, the electrical engineers, and the mechanical engineers. His present successor, Dr. Fink, followed ably with a joint meeting with the Illuminating Engineering Society and the Gas Institute, devoted to the contributions of chemistry to lighting. A full report is reserved for our next issue. Likewise the New York section of the American Chemical Society did a very creditable and timely thing through the excellent report of its Chemical and Dyestuff Committee. We are glad to print this report in full in the present issue.

Mexico

Nothing could be more hazardous than to predict the immediate political future of Mexico. It might be a pleasant pastime for as long as a day, but it would become wearisome to watch seriously the kaleidoscopic changes taking place in the southern republic. None but a keen and enthusiastic historian would care to chronicle and remember the unnumbered shifts of fortune. And yet peace and prosperity in Mexico are of the greatest immediate importance to the mining and metallurgical industry of the United States. Industrial and mining opportunities may and do exist in South America, but there are better known and proved opportunities nearer at hand in Mexico. Here is a rich field for the investor, the manufacturer of machinery and the operating engineer. To open it would be to relieve in a marked degree the depression here due to other causes, and bring prosperity to our own country as well as Mexico.

Under the domination of Villa, northern Mexico seems to be more nearly normal than any other part of the country; but even there the resumption of business is seriously handicapped by the disorganization due to several years of revolution. Shortage of labor is the most serious item. The native Mexican has never been noted for industry and close application to work, and several years of employment as a "soldier" have not improved his qualities as a laborer.

Nevertheless resumption of operations is proceeding at some mines and smelting plants. We are informed that the American Smelting & Refining Company is

again operating a few furnaces at Chihuahua, Asarco, and Monterey. The majority of cyanide mills are still closed, although in some cases the companies are keeping superintendents on the ground ready to begin work when conditions warrant.

At the time of writing there is some hope of immediate settlement of political conditions in Mexico. We recall, however, that plans for peace must involve the self-effacement of contending leaders, and it is a question whether we may reasonably expect such evidence of patriotism. That virtuous quality has not been conspicuous among Mexican revolutionists; the "liberator" is very patriotic until he sees national power in his grasp.

The Steel Trade's Prospects

Movements in the steel trade are traditionally difficult to forecast, and that this should be the case is readily understood when one reflects that the industry has rightly been called the barometer of general trade. How shall one undertake to forecast the movements of the barometer? One rather forecasts what the weather will be by observing what the barometer has done. The essence of the principle is that steel is the foundation of so many industries, entering into nearly all the operations of men, that as one industry after another prepares for activity it buys steel, and thus the various activities are focussed upon the one spot.

Between the date of production and the date of final ultimate consumption of steel a considerable interval must usually elapse, because for most uses steel undergoes somewhat elaborate processes of fabrication. As prices rise and fall buyers endeavor to take advantage of the fluctuations and thus the quantity of steel in progress from the rolling mill to the point of final consumption undergoes wide variations, wider than is generally recognized and running into the millions of tons. For instance, there have been times when steel cars were delivered to railroads before the traffic had grown sufficiently to require them, while at other times railroads have found themselves short of cars through a portion of their equipment proving unserviceable when suddenly called upon. By reason of this tendency of the quantity of steel in transit from the rolls to ultimate consumption to vary steel mill activity has fallen into a rhythm of long swings upwards and downwards. The experienced observer has frequently been able to determine what phase the wave was in at the moment, and thus prognosticate for the future.

It is said that all signs fail in dry weather and similarly all rules have fallen down in the face of the entirely new conditions brought about by the great war. Several times in the past fifteen years the steel industry has dropped to a rate of operating 50 per cent of capacity, and the attainment of such a low rate has been the signal that the rate was shortly to increase, but now the steel mills are operating at no more than about 35 per cent of capacity, a record low rate. The character of the movement, nevertheless, has been similar to that of movements in the past, in that the volume of material in transit from the mill to the point of final utili-

zation has shrunk to very small proportions. Confidence in values of steel and confidence that banking accommodations will be afforded have always been the forces operating to arrest the decrease and produce an increase in this volume of material. Both these forces must now be present. Steel prices are as low as they were three years ago, in November, 1911, when they reached the lowest level since the establishment of the present order of things, the lowest since 1898. To secure orders of consequence, to "start a buying movement," the mills are doubtless ready in most cases to make some further concessions. As to financial accommodations, the new Federal Reserve system, put in practical operation Nov. 16, is believed on all hands to be adequate to meet the situation.

An increase in stocks of steel in transit can afford only temporary assistance to the trade. Actual consumption and utilization must increase, and for this the various industries consuming steel must become more prosperous. It has been a state of mind, rather than a set of physical conditions that has kept industries throttled in the past few months. There has been a period of panic, of unreasoning fear, and this condition must yield, is yielding now, we believe, to analysis and recognition that in a material way we are but little injured. The observation so commonly heard of late that the tremendous destruction of property occasioned by the war is an economic loss, and must be met, is not in point at this time. The settlement must come, but it will come later. The usual effects of war are fear and prostration first, next feverish and temporary recovery, producing a "boom" towards the close of and immediately after the war, and then still later a collapse and a long period of making up for the losses.

Some industries have found already that they are benefited by the war. Few are directly injured, though many have been forced to accommodate themselves to new conditions. The recovery of most industries will be less by development of concrete conditions in material things, than by changes in the mental state, and as the minds of men are much the same whether they make breakfast food, typewriters or overalls, the change will sweep over nearly all industries in much the same manner. The mental change will be relatively swift. The war itself fits men's minds for quick changes. The consumption of steel will then increase, not perhaps to the normal average, but to a much greater rate than that of the past month or two.

The greatest cloud in the sky has been the fear that American securities held abroad would be returned in such quantities that we could not settle the account. The war, however, puts affairs on the basis of material things, no money no credit. England, for instance, would require gold only to pay for materials, and those materials must be drawn largely from this country. American manufacturers have already sold millions and millions of dollars' worth of goods to the belligerent nations, the only definite knowledge of the identity of the real buyer being the fact that the direct purchaser was a man or firm prepared to pay spot cash in New York funds.

Readers' Views and Comments

Fire Brick

To the Editor of Metallurgical & Chemical Engineering:

Sir: Referring to the article in your August issue by Mr. J. E. Johnson, Jr., as well as to my criticism and his reply which appeared in your November issue, I would like to make a further comment.

In his article Mr. Johnson states, "In very recent years fire brick manufacturers began to make furnace bricks 3 inches thick," and in the same paragraph states, "They are, therefore, very much to be preferred from practically all points of view, except that of cost. In this respect the brick makers have established certain customs, which have not been permitted to any other trade." In the following paragraph in his article he gives the reason for their so doing as being "apparently on the ground that he needs it, and he usually succeeds in getting it." This is manifestly unfair to the fire brick manufacturer in its implication.

In answer to Mr. Johnson I wish to state that the increase in the cost to the consumer of a 3-inch brick over the cost of a 2½-inch brick is based solely upon the increase in cost in manufacture. As stated in my former remarks, a brick 9 x 4½ x 2½ in. is the standard and has been for many years, and a brick of this dimension is the most economical size to make from the manufacturers' standpoint. This statement can be verified by referring to the Refractories Manufacturers Association, which is an association of fire brick manufacturers producing about 75 per cent of the fire brick manufactured in this country.

Fully 75 per cent of the fire brick manufactured are fire brick of the 9-in. series and take a base price, which includes arch, key, wedge, soap, split, etc. The remaining 25 per cent are either larger or smaller than the standard 9-in. and are for special purposes. To make a fire brick larger than the standard requires more time in both the drying and the burning, which means a loss of plant capacity.

Second, the per piece loss in both drying and burning of what is known as the blast furnace brick is approximately the same as the per piece loss of brick in the 9-in. series. As a blast furnace square is more than equal to two 9-in. brick, the loss would, therefore, be double. This statement can be verified by any fire brick manufacturer with a cost accounting system that enters into these details, which answers Mr. Johnson's statement with the reason why the fire brick manufacturer "needs it" and why "he usually succeeds in getting it."

Referring to that part of his article in which he states in relation to this increased cost that "the brick makers have established certain customs which have not been permitted to any other trade," I refer Mr. Johnson to the catalog of any steel company. The one which I have before me is headed, "Standard Classification of Extras on Steel Bars and Shapes." Immediately under this heading is a table of rounds and squares, and I note that sizes from ¾ in. to 3 in. take a base price per 100 lb. (I believe the conservative base price is \$1.25 per 100 lb.) A size ¼ in. under the minimum carries an extra of 10 cents per 100 lb. or \$2 per net ton, and 3/16 in. round or square carries an extra of \$2 per 100 lb. or \$40 per net ton.

Referring to those shapes larger than the shapes carrying a base price 3 1/16 in. to 3½ in., 15 cents extra per 100 lb. or \$3 per net ton; 6½ in. to 7¼ in., \$1.25 per 100 lb. extra or \$25 per net ton extra. The

extra which the fire brick manufacturer asks for a blast furnace shape, over his price for the standard 9 in., is less than 5 cents per 100 lb. or \$1 per net ton.

From the foregoing comparison, entirely based on facts, Mr. Johnson is absolutely unwarranted in writing an article inferring that the fire brick manufacturer has a moral code that is in any way inferior to that of the steel manufacturer, and the idea suggests itself to me that the least Mr. Johnson can do is to retract his statement reflecting on the business ethics of the fire brick manufacturer.

CHAS. S. REED.

Chicago Retort & Fire Brick Co.,
Chicago, Ill.

* * *

To the Editor of Metallurgical & Chemical Engineering:

Sir:—Referring to Mr. Reed's second letter I do not see that these comparisons of utterly dissimilar matters get us anywhere. It would be easy to show that the ratio of sizes of steel bars from the smallest to the largest which take the base price is 16 to 1 while the ratio of the sizes of firebrick on which a stiff differential is charged is only two to one. Also that the weight of the individual bars makes handling much more difficult in the large sizes owing to this vast disproportion of weight, which is not the case to anything like the same extent with brick, and that the amount of bars over three inches which are sold is insignificant as compared with the amount between that size and three-quarter inch, while the number of large brick in a furnace lining is two-thirds that of the smaller size.

But to point this out only shows the futility of Mr. Reed's comparison. I have reason to believe, however, that there may be logical and tangible evidence that it costs more to make the large brick than it does to make the small ones, though I have hitherto been unable to obtain the reasons of this from the brick manufacturers.

If I succeed now in obtaining it, I shall take pleasure in either publishing it myself or getting some reliable brick manufacturer to do it, and if it justifies their claims I shall be more than willing to admit the fact and to revise my attitude on this question. If I have done brick makers an injustice they have only themselves to thank as they have been unable or unwilling to explain on grounds that seemed reasonable to me, and I believe to most furnace men, why they charged this differential. If Mr. Reed's letters have the (very indirect) effect of causing this information to be brought out, we shall all, brick manufacturers and furnace men alike, have reason to be grateful to him.

J. E. JOHNSON, JR.

New York, N. Y.

Accelerator for Gasoline Gas Plants

To the Editor of Metallurgical & Chemical Engineering:

SIR:—In your issue of June, 1914, there was an article on accelerators for gasoline gas plants by Mr. C. J. Barton.

The writer has had the same experience as Mr. Barton with poor gas in the winter time with the exception that on very cold days nothing but air with a faint odor of gasoline came through the pipes.

The generator is about 30 ft. or 40 ft. from the laboratory and the compressed air, which is furnished from the plant and controlled by means of reducing valves, bubbles through the gasoline in the tank. The

pipe from the generator enters the building in the basement and goes up to the laboratory.

The accelerator, which is in the basement, consists of a rectangular 2-gal. tank. The pipe from the generator enters the accelerator at the bottom and the pipe to the laboratory is in the top. With this arrangement the lean gas enters at the bottom, bubbles through the gasoline and goes directly to the laboratory through the pipe in the top.

The accelerator is fitted with a stopcock in the bottom for drawing off the non-volatile liquid and a tight-fitting plug is screwed in the top for filling.

Not more than a gallon of gasoline is ever put into the accelerator and one filling will last for two days, except in very cold weather.

The furnace for heating the building is in another part of the basement and the accelerator is partitioned off with danger signs in conspicuous places.

H. P. KIMBER.

Bridgeton, N. J.

Potatoes and Salt

To the Editor of *Metallurgical & Chemical Engineering*:

SIR:—It is related of a certain vine grower that, dissatisfied with the modest living afforded him by the product of his labor, he consulted an oracle of his day as to a possible improvement of his fortunes.

"Dig in your vineyard for gold," was the somewhat vague answer he received. So he dug. Naturally he took care not to injure the roots of his vines. The pot of money he expected to find never came to light, but the vines renovated by the unaccustomed tillage responded with such an increase of yield that they surpassed all records, and proved to be the source of the "gold" of which the eager peasant was in search.

"Thus, my children," said the sage, in concluding his great moral illustration, "we see how we may fail to secure pecuniary emoluments by the attempted entrainment of extraordinary elements, while close at hand is an environment which properly exploited will yield to us the objects of our efforts."

For a hundred years chemists laboriously sought for phosphorus in the urine, and produced it a few grains at a time, while all the time tons of bones were available. The only trouble was they didn't know that bones contained phosphorus.

How long had man sought for a preventive or cure for yellow fever, before the humble "stegomyia," otherwise "skeeter," was discovered to be the "carrier"? And afterward, all attempts to extirpate him by death having failed, how simple and close at hand the device by which, obviating the painful necessity of his death, we gently and mercifully prevented him from being born!

Long have we dreamed, earnestly have we worked at the problem of synthetic rubber. Now a murmur is heard that it has at last "arrived." Whether as a commercial rival to the native article may indeed still be, as Kipling puts it, "another story." Many are the means proposed, but among them none is more promising, certainly not one is more simple than the method suggested by our humble title.

Potatoes! The harmless necessary spud. Salt! Condiment alike of man and beast. World-wide each, and familiar in our mouths as household words, such are the domestic elements that have modernly combined to bring about the realization of one of chemistry's most seductive fancies, artificial caoutchouc.

Here, with some reluctance, we have to announce that we cannot give proper credit for parts of the alleged discovery, and have therefore decided to make no authoritative citations. In fact, the war now raging has

stopped all communications with the countries most involved, and for the time being we have to content ourselves with such fragmentary information as had been developed at the time trouble began. We believe, however, that we are correct in distinguishing the three nationalities as below stated, as well as in the statement of the leading chemical principles involved.

Starting then with the potato, we risk no denial in saying that from it comes starch. From starch man has long since learned to produce alcohol, and from alcohol the jag. However, begging our reader's pardon, we wander a little from the subject. We do not have to get as far as the jag in any logical sequence having caoutchouc for its end.

The "alcohol" thus produced is, of course, our old friend ethyl alcohol C_2H_5OH . But one of the obstacles in the way of its production has always been the unwelcome presence of fusel oil, so called. This is well known to the chemist as amyl alcohol $C_5H_{11}OH$. Careful study of distillation methods has limited the percentage of the fusel oil obtained. Here comes the French contribution to the new discovery. Strictly speaking, this has no scientific bearing on the problem, for fusel oil has long been well known. However, the ingenious French chemist who is now in question seems to have reasoned thus: "If we know how to get a distillation with the minimum production of fusel oil, let us instead of trying to get rid of, multiply the conditions leading to its formation."

In short, the claim is said to be fairly established that the cost of fusel oil may now be reduced in the ratio of over three to one, roughly from about 30 cents a pound to 10 cents.

"But where does your rubber come in?" Patience, we haven't got to that yet.

We must now quit the hillsides of vine-covered France and cross the Rhine. Alas, it may be that the German chemist who is responsible for the next step in the synthesis has already fallen in the brunt of battle, and his French contemporary in the stress of strife. It may be that even the English discoverer to be presently brought in has been swept away, and this terrible war may have to its debit the loss of a great industrial discovery at the very crisis of its development. For, though the outlines have been fairly set forth, it has not been claimed that commercial competition had been yet approached, albeit some of the product had been actually tested even in auto tires and had been pronounced excellent.

Our information as to the next step is scanty. This much is known, viz., that iso-amyl chloride (itself, of course, formed by the action of some chloride on the amyl alcohol) is first produced. Isoprene, the next objective point in the synthesis, has been produced from amyl alcohol. The broad statement that it is produced by the "action of chlorine" hardly satisfies the chemist's longing for technical detail. It is quite possible that some further operative detail has appeared which has escaped our attention, as we have not access to every current source of chemical information.

Isoprene is credited with the formula C_5H_8 . Rubber has always been written as its polymer, $C_{50}H_{80}$. As usual, there was no great difficulty in getting rubber to dissociate into isoprene. There was difficulty amounting to impossibility in getting isoprene to build itself by internal molecular union into rubber!

Parenthetically, we may say that it is easy enough to represent various reactions by equations, without deriving much practical knowledge from the latter. A multitude of equations represent merely the initial and final stages of some transformation. We do not attempt here to "equate." Furthermore, we are well aware that other methods of obtaining isoprene have been pub-

lished. As they do not fit into this scheme they are passed by.

Isoprene, it is claimed, has been transformed into rubber by methods which include a time element so great as to be fatal to commercial success. The latest discovery, however, eliminating the time factor as is claimed, comes from England. This has become familiar, but as we have started out to make this sketch impersonal, we can hardly violate the rule in any one case. The discovery was made as follows: Isoprene is difficult to dry, some water being so intimately intermixed or combined that it cannot be driven out by heat without decomposition of the main body. In seeking to remove the last of this water, metallic sodium was employed.

A wire of the metal was laid in a test tube filled with the liquid isoprene, the tube being corked. A remarkable catalysis developed. The isoprene polymerized into rubber!

But how does it accomplish this? It may be seriously doubted whether anyone is competent to explain mysterious reactions of this kind. The modern school regards molecules as very heavy artillery, quite unfit to open an action. But when it comes to catalysis (recently a reaction has been cited where one part in seventy millions effected the transformation), then, like Richard II, we do indeed "stand amazed." Our chemical equations seem as much out of place as catapults on a modern battlefield.

But our title is justified. Let us briefly review the steps of this synthesis.

We need not be particularly scientific or even technical to be understood.

CHAPTER I

Potatoes. Starch. Fusel oil. The latter more cheaply obtained than hitherto.

CHAPTER II

Fusel oil. Iso-amyl chloride. Isoprene.

Chlorine the essential element in this part of the evolution.

CHAPTER III

Sodium the efficient agent for transforming isoprene into caoutchouc.

CHAPTER IV

Chlorine and sodium form common salt. More correctly, sodium and chlorine are derived from salt.

Potatoes furnish the material. Salt furnishes the two active agencies.

Why then search air, ocean, and earth for something "new and strange" when we can find the elements for our most startling synthesis in that humblest meal of the lowly: "Potatoes and salt."

REGIS CHAUVENET.

Denver, Colorado.

Cyanide Practice in the Porcupine District

To the Editor of Metallurgical & Chemical Engineering:

SIR:—I note Mr. Parmelee states in your November issue that in his article on cyaniding in the Porcupine district in the October number he had credited Dorr classifiers to the McIntyre Mill and Colbath classifiers to the Dome, whereas it should have been the reverse.

To bring the description up to date and in the interest of accuracy you may care to state that the McIntyre mill has replaced the Colbath with a Dorr classifier and has just ordered an additional one to handle their increase in capacity.

This exemplifies the difficulty of having a description correct when it is published, for Mr. Parmelee's article was probably based on his visit made last June.

H. N. SPICER.

Dorr Cyanide Machinery Co., New York City.

The Iron and Steel Market

November has been the poorest month the steel trade of the United States ever experienced. Actual purchases of steel have not equalled 25 per cent of the productive capacity, while actual production dropped from a rate of about 40 per cent of capacity at the beginning of the month to a rate of less than 35 per cent at the close.

These conditions have never before been paralleled in history.

The reduction of stocks in the hands of jobbers and manufacturing consumers has been unparalleled, the influences being a distrust of values, as steel prices were constantly falling, a doubt whether material would be needed at all in the near future, the war inducing a panic preventing judgment from being exercised, and difficulty in carrying material by reason of the almost complete lack of banking accommodations.

The war has affected the minds of men much more than it has affected material things. It did not prevent the crops maturing and it is not now greatly affecting the importation and exportation of merchandise. The collective mind has passed through many stages. Upon the announcement of war there was a sudden fright, followed by a view that prices would advance and many materials become scarce, this resulting, about the middle of August, in some price advances in steel and a small-sized buying movement. Later, with a full realization of the horrors of war and the complete dislocation of trade promised there succeeded a period of panic, of unreasoning fear, which resulted in constantly decreasing buying, up to the beginning of November, when the irreducible minimum appears to have been reached at last. Since the beginning of November the mental attitude has greatly improved. Almost everywhere a more cheerful feeling is to be observed and the greatest barrier to a recovery in trade has been removed.

Steel prices continued to fall throughout November, until at the close of the month the average level was as low as three years earlier, when the lowest point was reached since 1898. The burden upon steel manufacturers is vastly greater now than then, for wages are higher, through the general advance of early in 1913, and the cost of production is also increased by the lowness of the rate of operation, not over 35 per cent of capacity, against about 75 per cent in November, 1911.

Many steel interests have not been earning their fixed charges.

The decline in activity and prices seems now to have run its course. A mild improvement in buying is to be expected for December, and after the turn of the year more rapid progress is likely to be made. In many quarters it is believed that in April the mills will be operating at double the present rate, though few expect full operation in the industry before the close of the war.

Export trade in iron and steel has been increasing, but is still relatively light. South America was formerly our best country, but is now prostrated. The exports now being made are largely along a new line of trade, involving in large part war materials to countries that hitherto have not bought iron and steel from us in any large quantity. Barb wire, lathes, steel rounds for shrapnel, light rails with ties for portable railway, are examples of such material. Iron and steel exports in December promise to exceed 100,000 tons, against an average of 140,000 tons a year in the first six months of this year, 114,000 tons in July, 86,000 tons in August and 96,000 tons in September.

Pig Iron

While November showed no material increase in steel buying, there was a distinct increase in pig iron buying. The Buffalo district reports large sales of foundry iron, while in the valleys and the St. Louis districts there have been fairly large purchases of basic iron by steel foundries, though practically none by steel rolling mills. Pig iron prices declined slightly about the beginning of November, but afterwards became practically stationary, at the lowest level since 1904. The rate of production, after a long decrease, appears to be approximately stationary.

The market is quotable as follows: No. 2 foundry, Birmingham, \$10; delivered Philadelphia, \$14.45; f.o.b. furnace, Buffalo, \$12; f.o.b. furnace, Chicago, \$12.50; at valley furnaces (95 cents delivered, Pittsburgh, by the recent five-cent freight advance): Bessemer, \$13.75; basic, \$12.50; No. 2 foundry and malleable, \$12.75 to \$13; gray forge, \$12.50 to \$12.75. England has placed conditional embargoes on manganese ore exports from India and ferromanganese exports from England, but consumption is so light that the market has not been disturbed, there being large stocks. The nominal price is \$68, Baltimore.

Steel

The market for unfinished steel has weakened even though there has been no serious enquiry to tempt reductions. It is well established that for early delivery at least billets can be had at \$19 and sheet bars at \$19.50, f.o.b. maker's mill, Pittsburgh or Youngstown, rods being \$25, Pittsburgh. On prompt lots these prices could probably be shaded, but on the other hand it is not certain that contracts could be made at such figure for first quarter.

Finished Steel

During the month bars, plates and shapes declined about \$1 a ton, iron bars dropped irregularly and black and galvanized sheets declined \$1 a ton. On November 1 the extra 2½ per cent discount to jobbers in steel pipe was removed, while the basing discount was increased one point, effecting a net reduction of about \$1 a ton.

Current prices as closely as can be quoted are as follows, f.o.b., Pittsburgh, unless otherwise noted. In the Chicago district and in the east many products are sold at delivered prices equivalent to less than the Pittsburgh base prices here quoted.

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.05c. to 1.10c.

Shapes, 1.10c.

Steel bars and bands, 1.10c.; hoops, 1.25c.

Refined iron bars, 1.20c., Pittsburgh; common iron bars, 1.10c., Philadelphia; 0.95c., Chicago.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 gage, 1.85c.; galvanized, 28 gage, 2.85c.; painted corrugated, 28 gage, 2.05c.; galvanized corrugated, 28 gage, 2.90c.

Steel pipe, ¾ to 3-in., 81 per cent off list.

Standard railroad spikes, 1.35c., Pittsburgh; 1.45c., Chicago.

Structural rivets, 1.45c.; boiler rivets, 1.55c.

Cold-rolled shafting, 67 per cent off list.

Chain, ¾-in. proof coil, 3.00c.

Gas-Engine Driven Compressors.—The C. & G. Cooper Company, of Mount Vernon, Ohio, are supplying a 950-hp twin tandem gas engine to the Medina Gas & Fuel Company for the Mansfield, Ohio, station. This will be the third Cooper unit in the plant. The Ohio Fuel Supply Company have also ordered three 475-hp single tandem gas-engine driven compressors.

The Western Metallurgical Field

Cyanide Consumption in the United States and Canada

For some months past there has been considerable speculation as to the quantity of sodium and potassium cyanides consumed in the metallurgical industry in the United States and Canada. Various estimates have been given, based on the tonnage of ore treated and the probable average consumption per ton of ore, but no wholly satisfactory figures have been published.

Fortunately the United States Geological Survey began in 1911 to include in its statistics on gold and silver production, the consumption of sodium and potassium cyanides, and has continued that commendable policy through 1912 and 1913. Excepting California and Oregon, data are complete for all states in which cyaniding is practiced even as a minor metallurgical process. The two states mentioned are not large consumers of cyanide, as amalgamation and smelting probably account for the recovery of the major portion of their total production of precious metals. Cyanidation is gaining a foothold in these states, but the quantity of cyanide consumed would not greatly affect the total for all states.

Neglecting definite figures for California and Oregon, and combining the figures for Texas and Wyoming with those for New Mexico and South Dakota, respectively, we believe the following table compiled from United States Geological Survey statistics, gives the most complete and reliable data yet published.

State	1911 Pounds	1912 Pounds	1913 Pounds
Arizona	115,877	129,987	189,291
Colorado	759,149	837,537	919,963
Idaho	181,808	161,156	94,475
Montana	91,657	93,344	116,422
Nevada	2,352,961	2,618,424	2,798,224
New Mexico	165,396	147,035	207,605
South Dakota	599,845	580,231	505,142
Utah	205,041	203,721	70,288
Washington	9,700	36,517	32,090
	4,481,434	4,807,952	4,933,450

New Mexico for 1913 includes small quantity from Texas.

South Dakota for 1912 and 1913 includes small quantity from Wyoming.

With California and Oregon added, the grand total for 1913 would be, roundly, 5,000,000 lb. The figures given show increased consumption of 7 per cent in 1912 over 1911, and 2.6 per cent in 1913 over 1912. From 1911 to 1913 the consumption increased roundly 10 per cent. It seems likely that these figures are accurate, for while other statistical data gathered from operators may be subject to error through estimates, it is likely that individual consumers can ascertain with considerable certainty how much cyanide they purchase and use. It is to be hoped that the Geological Survey will extend this useful work in California and Oregon, so that we may know accurately how much cyanide is consumed in the treatment of precious-metal ores.

The consumption in Canada is clearly set forth in a communication from Mr. J. McLeish, chief of the statistical division of the mines branch, Department of Mines, Ottawa, as follows:

"Direct returns have not been received from Canadian mining companies with respect to their consumption of cyanide, but in view of the fact that there is no local production, a fairly accurate estimate of the consumption in Canada will be furnished by the record of imports, a detailed statement of which is attached hereto.

"The imports of all cyanides for metallurgical purposes in 1911 totaled 308 tons, or an average of about 25 tons per month. The imports in 1912 totaled 475 tons, or an average of nearly 40 tons per month. The imports in 1913 totaled 708 tons, or an average of 59 tons per month. During the first six months of 1914 the imports totaled 227 tons, or an average of only 38

tons per month, but in the month of August the imports increased to 130 tons. These figures should represent approximately the Canadian consumption of cyanide."

IMPORTS INTO CANADA OF CYANIDE OF POTASSIUM, CYANIDE OF SODIUM, AND CYANOGEN BROMIDE FOR REDUCING METALS IN MINING OPERATIONS.

1913	Pounds	Value
January	84,512	\$12,648
February	19,407	1,492
March	160,134	24,174
April	77,170	11,566
May	80,415	12,235
June	178,025	28,197
July	71,267	13,784
August	183,498	27,802
September	89,806	13,556
October	208,966	31,559
November	142,099	21,026
December	129,370	19,433
Total	1,415,669	\$217,472
1914		
January	177,392	\$25,363
February	134,413	19,270
March	143,069	20,116
April	82,954	11,540
May	193,241	28,113
June	96,757	14,038
July	96,377	13,333
Total 6 months	454,874	\$64,749
August	260,799	\$46,513
Total for 1911	615,607	\$94,397
Total for 1912	950,238	\$143,978

Of the gold and silver producing districts of Canada, Cobalt and Porcupine are by far the most important. According to figures compiled by Mr. A. A. Cole, mining engineer for the Temiskaming & Northern Ontario Railway Commission, Cobalt is consuming about 50 tons of cyanide per month and Porcupine about 20 tons. Mr. Cole has communicated this and other information to the Canadian Mining Institute, from the November *Bulletin* of which we taken the following notes: On the outbreak of the war it was found that with one exception all the northern Ontario mining companies were getting their cyanide from the Cassell Cyanide Company, Ltd., of Glasgow, Scotland. To this company the British government suggested the policy which is now being followed with respect to sales of cyanide, viz., to sell none of this chemical outside the British Empire until first the gold and then the silver mines within the empire have been supplied. The Cassell company is now making additions to plant, but it will be some months before increased output can be made. The price of cyanide in Ontario is now 18 cents per pound, having risen 3 cents per pound since the opening of the war. The Cassell company is now offering, however, to supply the mines with cyanide for the next two years at 18 cents per pound, and at 16 cents during 1916, providing the mines will agree to buy all their cyanide from this company alone during that time. It appears now from Mr. Cole's estimates that within a year the consumption in northern Ontario will be at the rate of 100 tons per month, or 2,400,000 lb. per year, which is almost half the 1913 consumption in the United States.

Determining Percentage of Gold in Quartz

In a discussion before the Teknik Club, of Denver, on the subject of determining the percentage by weight of gold in a specimen of free gold in quartz, it was pointed out that at least half a dozen formulas have been published for the solution of the problem. Some of these formulas are obviously incorrect; others are of doubtful value, as their derivation is obscure. The simplest form of correct formula for solving this problem requires only a knowledge of the specific gravities of the constituents and the specimens. It is assumed, of course, that the specimen consists of practically pure constituents. If we let

- G_1 = sp. gr. of the specimen,
- G_2 = sp. gr. of gold, and
- G_3 = sp. gr. of quartz.

then the percentage of gold in the specimen can be determined from the following formula:

$$x = \frac{100G_2(G_1 - G_3)}{G_1(G_2 - G_3)} \quad (1)$$

If, for example, we have a specimen of sp. gr. 5, and take the sp. gr. of gold as 20, and of quartz as 2.5, then

$$x = \frac{100 \times 20(5 - 2.5)}{5(20 - 2.5)} = 57.1 \text{ per cent gold in specimen.}$$

If a simple arithmetical proof is required, it can be given as follows: Under the conditions assumed

- 1 cc gold weighs 20 g.
- 6 cc quartz weighs 15 g.
- 7 cc specimen weighs 35 g.

$$\text{Sp. gr. of specimen then} = \frac{35}{7} = 5$$

$$\text{Percentage of gold} = \frac{20}{35} = 57.1.$$

Another formula which has been wrongly supposed to give the solution of this problem is

$$x = \frac{100(G_1 - G_3)}{G_2 - G_3} \quad (2)$$

Applying this formula to the problem assumed above we get 14.3 per cent, an incorrect answer. As a matter of fact, 14.3 represents the percentage by volume of gold in the specimen (being one-seventh, as shown above), and the percentage by weight can be calculated from the volumes and specific gravities of the constituents.

Formula (2), however, is correct for obtaining the percentage by weight of a concentrate obtained from treatment of a simple ore consisting of one mineral and gangue, when assays of ore, concentrate and tailing are known, letting

- G_1 = Head assay,
- G_2 = Concentrate assay, and
- G_3 = Tailing assay.

Still another application of formula (1) is in the determination of the per cent of solids in, say a cyanide pulp, where

- G_1 = Sp. gr. of the pulp,
- G_2 = Sp. gr. of the dry solid, and
- G_3 = Sp. gr. of water, or 1.

The formula then becomes

$$x = \frac{100G_2(G_1 - 1)}{G_1(G_2 - 1)}$$

Company Reports

Camp Bird Limited has issued an annual report for the year ended June 30, 1914. A grave crisis in the company's affairs arose during the year due to the failure of the Canadian Agency, Ltd., Messrs. Chaplin, Milne, Grenfell & Company and Mr. A. M. Grenfell. Changes in the administration of the company since that time have resulted in economies amounting to between \$9,000 and \$10,000 per annum. Mr. R. J. Frecheville resigned as a director and was made chairman of the technical committee, which has charge of the company's mines. The other members of the committee are Messrs. J. A. Agnew and L. Chevrillon. In regard to the Camp Bird mine, the statement is made "that the development work in the bottom of the mine has not shown any considerable addition to the ore-reserves." In the Santa Gertrudis mine, development on the main vein at the lowest levels has not been encouraging, but on the other hand some very encouraging ore-bodies parallel to the main vein have been discovered. Ore reserves at June 30 were estimated at 1,194,000 tons. The Messina (Transvaal) Development Co., Ltd., was plunged into severe difficulties by the financial failures referred to, but is expected to solve its own financial

difficulties. The estimated ore reserves developed to the ninth level are 247,000 tons of 9 per cent copper ore. The mine and plant are in first-class condition. With respect to the Central American Goldfields Syndicate, Ltd., difficulties have arisen over title to property and litigation is imminent. Operations have been suspended for the present.

The Camp Bird mill treated 30,595 tons of ore during the year, yielding an average of \$26.19, as against \$22.51 in the year previous. The extraction was 94 per cent. Of the total extraction, 52.97 per cent was by amalgamation, 42.07 per cent by concentration and 4.96 per cent by cyanidation. The value of the ore treated was distributed as follows: gold, 87.49 per cent; silver, 9.01 per cent; lead, 1.67 per cent; copper, 1.83 per cent. The metal content of the ore was as follows: gold, 1.135 oz. per ton; silver, 4.27 oz. per ton; lead, 1.324 per cent; copper, 0.260 per cent. The gross value recovered in the stamp mill was \$761,330; net recovery, \$710,234. The cyanide mill recovered \$39,748 gross, or \$12,379 net. Total net recovery, \$722,603.

At the Santa Gertrudis property the Guadalupe mill remained closed. During the year 233 flasks of quick-silver were recovered from the old patio. The new mill was in operation until the 21st of April, when the American occupation of Vera Cruz caused a suspension of transportation facilities and an exodus of the foreign staff. The plant remained idle during the balance of the year, but was opened again on July 6, 1914. The crushing rate was 28,660 tons in July, 1913, 32,849 tons in March, 1914, and is now about 20,000 tons per month.

The quarterly report of the **Ray Consolidated Copper Co.** for the third quarter of 1914, shows an average monthly production of copper in concentrates of 4,158,384 pounds, as against an average of 6,249,448 pounds per month during the preceding quarter. Ores shipped direct to smelters contained 161,032 pounds of copper, bringing up the total production for the quarter to 12,636,185 pounds. A 50-per cent reduction in output was inaugurated August 5, due to the European war. The ore treated during the quarter averaged 1.691 per cent copper. The recovery was 67.47 per cent. The milling cost was 45.85 cents, compared with 47.24 cents for the second quarter and 53.15 cents for the first. The average mining and coarse crushing cost was 57.681 cents per ton, of which 2.814 cents was for coarse crushing. This is a reduction of 7 cents compared with the preceding quarter. The average cost of copper, after allowing for smelter losses and applying the dividends from the Ray & Gila Valley Railroad, but no other miscellaneous income as a credit to costs, was 8.849 cents per pound. If all miscellaneous incomes were credited as a reduction of cost the figure would be 8.738 cents per pound. Low costs are being maintained in spite of reduction in capacity. At both mine and mill men have been employed on alternate days in order to provide employment for the largest number and to maintain the operating organization.

The **Utah Copper Company's** report for the third quarter of 1914 shows a marked decrease in tonnage of ore treated and copper produced. The average monthly production for the quarter was 9,562,224 pounds of copper. The September production was only 6,672,194. The tonnage treated was 1,466,606 tons as compared with 2,006,157 tons for the preceding quarter. The Magna plant milled 77 per cent and the Arthur 23 per cent. Since August 7 the Arthur plant has been closed. The average grade of ore milled was 1.4356 per cent; the average extraction was 68.13 per cent. The cost per pound of copper produced was 7.76 cents, as compared with 7.539 cents in the previous quarter. Crediting miscellaneous income, the cost per pound of copper is 6.951 cents.

The **Nevada Consolidated Copper Company** shows in its third quarterly report for 1914 the same conditions of curtailment of production as indicated above for the other copper producers. The average monthly production for the third quarter was 3,752,807 pounds of copper, the output in September being 2,718,471 pounds. The output in March was 5,218,227 pounds. During the quarter 599,126 tons of ore was milled, averaging 1.52 per cent copper. In addition to this tonnage, the company also milled 11,322 tons of Giroux ore. The cost per pound of copper after crediting miscellaneous income was 9.59 cents, as compared with 10.73 cents for the previous quarter.

The reduced cost is due to the higher grade of ore treated.

The report of the **Chino Copper Co.** for the third quarter of 1914 shows a gross production of copper in concentrates of 11,491,120 pounds, as compared with 17,032,871 pounds in the preceding quarter. The September production was 3,237,869 pounds, compared with 6,109,888 pounds in April. Besides copper in concentrates there was produced in direct smelting ore 286,693 pounds of copper. The total tonnage of ore treated was 390,000, the average grade being 2.165 per cent copper. Average extraction was 68.04 per cent. The concentrates averaged 16.79 per cent copper. The cost per pound of net copper produced from milling operations, without allowing credits from miscellaneous income, was 7.81 cents. During this quarter, for the first time since the beginning of operations, the quantity of gold in concentrates was sufficient to receive consideration from the smelter. The net credit from this source amounted to 0.10 cents per pound of copper. Crediting all miscellaneous income, the cost per pound was 7.37 cents. The cost of operations is being maintained at a low figure in spite of curtailment of output; thus the cost for September, on half capacity, was 6.65 cents per pound of copper produced, without crediting miscellaneous income. The new primary crushing plant has been put in operation at the mine and has been of assistance in increasing efficiency.

The Non-Ferrous Metal Market

Toward the end of November a distinct improvement was noted in the metal market. Prices for lead, copper and spelter advanced and more business was transacted. The London metal exchange opened on November 9. Export of copper has been affected by the British government in detaining copper shipments with the idea of preventing them from reaching a possible market in Germany. The action has caused loud protests from American copper producers, and our government has been urged to take steps to maintain such foreign market as exists.

Copper.—Business has been more brisk and domestic demand is good, especially among Connecticut consumers in the brass industry. Prices have been rising from 11 cents to nearly 12. The latest available quotation is about 11.87½ cents, New York.

Lead.—Good business has been done both in New York and St. Louis. The metal is quoted at 3.60@3.62½ cents, St. Louis, and 3.65@3.75 cents, New York.

Tin.—This market has been strong for immediate delivery. Spot supplies are apparently scarce and futures not in demand. The market has been active at about 34¼ cents, New York.

Spelter.—This metal was one of the last to share in the general market improvement, but demand has increased and prices have risen to 4.95@5.00 cents, St. Louis, and 5.10@5.15 cents, New York.

Other Metals.—The aluminum market continues without feature, and quotations are unchanged at 18 @ 18.5 cents, New York. Prices for various brands of antimony range from 12 to 18 cents, New York, with comparatively small stocks of metal available. The quicksilver market has fallen since our last report, importations from Europe having added to the supply. Flasks of 75 lb. are sold at varying prices, averaging about \$43, though a wider range in bid and ask prices.

Obituary

William Lofland Dudley died on September 8, 1914, en route from Clifton Springs Sanitarium to his home in Nashville, Tenn., after a sudden stroke of paralysis. He was born on April 16, 1859, in Covington, Ky., and educated in the public schools of Covington and the University of Cincinnati, from which he graduated as B.S. in 1880. (The same institution conferred on him last year the degree of Doctor of Laws.) At the University of Cincinnati he studied with F. W. Clarke, then professor of physics and chemistry. He was then demonstrator of chemistry, and after a year professor of chemistry and toxicology at the Miami Medical College of Cincinnati, which conferred on him the honorary degree of Doctor of Medicine. In 1887 he accepted the professorship of chemistry at the Vanderbilt University in Nashville, Tenn., where the main work of his life was done, until poor health forced him to retire from active work two years ago. He carried out a very large amount of chemical research leading into the most varied fields of chemical science. But he was a much bigger and broader man than a mere chemist. He was fond of art, especially music and literature, active in civic affairs, and loved clean sport. He organized the Southern Intercollegiate Athletic Association, and the athletic field at Vanderbilt University is called Dudley field. After his friend Dr. Kirkland became chancellor of Vanderbilt University, Dr. Dudley became dean of the medical school and thoroughly built it up. He never married.

* * *

Frederick Augustus Heinze, who for many years was a spectacular figure in the mining industry, particularly in Butte, Mont., died at Saratoga Springs, N. Y., November 4, at the age of forty-five. As a young engineering graduate of the Columbia School of Mines in 1889, Mr. Heinze went to Butte, where he subsequently founded the Montana Ore Purchasing Co. and established a profitable smelting industry. This venture was based on his firm belief that a smelting business in that district could be made a profitable business and it was the foundation of the fortune which he afterward accumulated. During his career he was involved in litigation almost constantly with the large companies of Butte, and the political history of Montana at that time gives evidence of the extent to which agencies of all kinds were involved in suits and controversies. In 1902 Heinze consolidated his interests in the United Copper Co., and about four years later the fight between him and the Amalgamated Copper Co. was terminated by the sale of his properties to this concern. After this he went to New York City and engaged in several financial ventures, establishing the Stock Exchange firm of Otto C. Heinze & Co., and purchasing control of the Mercantile National Bank. High finance was apparently breaking right for Mr. Heinze when, in 1907 his various financial houses failed and he was ousted from the presidency of the Mercantile National Bank. From the wreck of his various mining and financial ventures he saved mainly the Stewart mine in Idaho and the Mascotte tunnel in Utah.

Mr. Heinze was married in 1910 to Mrs. Bernice G. Henderson, who died within about two years. A son, F. Augustus Heinze, Jr., survives.

* * *

David J. Kelly, of Salt Lake City, died at his home on October 10, 1914, aged 37 years. He was a native of Utah and an engineering graduate of the University of Utah, receiving the mining engineer's degree. He was identified with various phases of the mining industry, having been assayer for the Salt Lake branch of the Kansas City Consolidated Smelting & Refining Co., and later with George Moore at Sunshine, Utah. Mr. Kelly became widely known in the metallurgical industry through his invention and development of the Kelly filter press, which finally attained prominence and success after a number of years of financial and mechanical difficulties. He is survived by a widow and two sons.

* * *

Douglas S. Martin, who relinquished his position on the editorial staff of the *Electrical World* in August to enroll in the forces of Great Britain, has succumbed to shrapnel wounds received at the battle of Messines on the Belgium border. Mr. Martin was graduated as an electrical engineer from the Central Technical College, London, England, and was formerly editor of the *General Electric Review*. After resigning from that paper he engaged in electrical work in the Far West, and on returning East joined the editorial staff of the *Electrical World*. Mr. Martin was twenty-seven years of age. He was a brother of Mr. T. C. Martin, secretary of the National Electric Light Association.

International Engineering Congress

A report having been recently circulated to the effect that the International Engineering Congress, San Francisco, 1915, would be abandoned, the officers of the Congress have announced that the rumor is incorrect and that the Congress will be held as scheduled, September 20 to 25, 1915.

In view of the conditions now prevailing in Europe, the governing bodies of the five National Societies under whose auspices the Congress is to be held, have recently given careful consideration to the feasibility of holding the Congress and to the probability of its success, with the result that each body has unanimously confirmed its original pledge to support the Congress. The Committee of Management is actively proceeding with arrangements, which are now well advanced, for meetings on the scheduled dates and for the publication of the transactions.

The Committee of Management is in receipt of a sufficient number of communications from various foreign countries throughout the world, including those located within the war zone, to indicate that a large majority of the papers originally requested for presentation at the sessions of the Congress and publication in its transactions will be handed in on time, and that the Congress will be truly international in character.

Fuel Oil.—We have received from Messrs. Tate, Jones & Company, Inc., of Pittsburgh, Pa., their recent illustrated bulletin on Appliances for Burning Fuel Oil. After an introduction on the economies of oil as fuel and on actual results obtained with oil for steam raising and in furnace work, the first main part of the bulletin deals with standard oil burner designs, because success with oil fuel depends upon the burner. The second part describes systems for pumping, heating and regulating oil flow at burners.

The Heat Balance of the Blast Furnace

BY SIDNEY CORNELL

Much has been written in relation to the modern blast furnace, and articles dealing with blowing in, furnace practice, and the effect of this and that condition on the furnace working are commonly seen in various papers.

Constant and systematic records are kept in most blast furnace plants of blast temperature, amount of free air blown, analysis of materials, the products of the furnace, etc., but these records seem to be for use when trouble occurs. A heat balance is useful and instructive, and can usually be figured from the data obtainable from the permanent records.

The following data was collected from a well-known plant of six 600-ton blast furnaces and average figures taken to effect the heat balance.

Table No. 1 contains the data of materials charged, together with material made, cooling water used, etc., and is arranged under the four headings: Tons per day, pounds per ton of pig iron made, tons per charge, and pounds per charge. A furnace making 445 tons of pig iron per day has sixty-four charges charged per day, which makes a period of $22\frac{1}{2}$ minutes per charge. Accordingly a test period of $22\frac{1}{2}$ minutes is taken and the heat balance figured accordingly.

TABLE NO. 1

	Tons per day	Pounds per ton pig	Tons per charge	Pounds per charge
Group No. 3.....	457	2,302	7.14	16,000
Group No. 4.....	174	878	2.72	6,100
Group No. 7.....	113	575	1.78	4,000
Buffalo.....	100	503	1.56	3,500
Open hearth cinder.....	57	287	.89	2,000
Flue dust charged.....	20	100	.31	700
Roll scale.....	20	100	.31	700
Flue dust loss.....	45.5	230	.71	1,600
Coke charged.....	457	2,302	7.14	16,000
Coke breeze in yard.....	7	34	.11	240
Total coke.....	464	2,336	7.25	16,240
Limestone.....	205	1,036	3.21	7,200
(Cubic feet)				
Wind @ 90° F. cf.....	42,188	.....	.....	.....
Pig iron made.....	446.28	2,247	6.97	15,620
Runner scrap.....	1.28	7	.02	50
True pig iron.....	445	2,240	6.95	15,570
Gallons				
Cooling water.....	2,571,240	47,960	148.70	333,350
True slag.....	267	1,344	4.17	9,340

In the figuring of a heat balance two conditions present themselves, viz., whether the blast furnace gas is cleaned before using or not, and whether the blowing engines are steam operated or gas driven. In the case of gas-driven blowing engines the gas must be cleaned, and further it is reasonably certain that cleaned gas gives better efficiency in the blast furnace stoves and boilers. In the plant where this data was collected both conditions were available and accordingly the necessary data was obtained.

Table No. 2 contains miscellaneous data necessary in figuring the heat balance, temperature, etc., and Table No. 3 the analysis of materials charged and produced.

TABLE NO. 3

	Ore	CaO and Li ₂ O	Al ₂ O ₃	MgO	MnO	P	H ₂ O	Fe	O ₂	C
Group No. 3.....	6.29	3.53	18	.63	.066	13.0	49.40	21.17	....	....
Group No. 4.....	6.26	2.35	.22	.75	.053	15.0	47.21	20.29	....	....
Group No. 5.....	10.50	3.90	.20	.30	.077	12.0	45.40	19.50	....	....
Buffalo	5.81	2.70	1.60	.40	.089	12.0	51.40	22.10	....	....
Open hearth cin- der	19.50	3.20	36.60	8.00	.950	2.0	15.00	3.00	....	....
Flue dust charged	8.50	3.70	3.00	.50	.065	10.0	50.20	19.07	9.00	....
Roll scale	1.00	1.0	1.00	.40	.065	7.0	66.25	18.00	....	....
Flue dust made..	9.50	4.11	3.33	.56	.070	....	55.80	....	16.00	....

	CaO and Li ₂ O	Si Al ₂ O ₃	MgO	Fe.	C.	P.	H ₂ O	O ₂	S.	N ₂	H ₂
Limestone. 2.95	1.90	53.20	....	....	....	.051	1.5	....	....	....	....
Lime	5.03	3.18	....	1.04	86.98	.023	2.8	.40	....	.30	.50
Coke	1.05	....	....	....	3.41	.294	....	....	.038	....	....
Pig iron. ....	....	....	....	....	....	....	....	....	....	....	....

	CO ₂	CO.	H ₂	N ₂
Blast furnace gas	13.06	25.70	3.69	57.45

TABLE NO. 4.

Weight taken in pounds per charge. 22½ minutes.																									
Material	SiO ₂		Al ₂ O ₃		CaO & MgO		MnO		Fe		C		P		H ₂ O		O		Z		N		H		
	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	Weight	%	
Group No. 3 ore	18,000	6.50	3,600	2.00	18,000	1.8	18,000	1.8	18,000	1.8	18,000	1.8	18,000	1.8	18,000	1.8	18,000	1.8	18,000	1.8	18,000	1.8	18,000	1.8	
Group No. 4 ore	16,000	6.50	3,200	2.00	16,000	1.8	16,000	1.8	16,000	1.8	16,000	1.8	16,000	1.8	16,000	1.8	16,000	1.8	16,000	1.8	16,000	1.8	16,000	1.8	
Group No. 5 ore	14,000	6.50	2,800	2.00	14,000	1.8	14,000	1.8	14,000	1.8	14,000	1.8	14,000	1.8	14,000	1.8	14,000	1.8	14,000	1.8	14,000	1.8	14,000	1.8	
Group No. 6 ore	12,000	6.50	2,400	2.00	12,000	1.8	12,000	1.8	12,000	1.8	12,000	1.8	12,000	1.8	12,000	1.8	12,000	1.8	12,000	1.8	12,000	1.8	12,000	1.8	
Group No. 7 ore	10,000	6.50	2,000	2.00	10,000	1.8	10,000	1.8	10,000	1.8	10,000	1.8	10,000	1.8	10,000	1.8	10,000	1.8	10,000	1.8	10,000	1.8	10,000	1.8	
Group No. 8 ore	8,000	6.50	1,600	2.00	8,000	1.8	8,000	1.8	8,000	1.8	8,000	1.8	8,000	1.8	8,000	1.8	8,000	1.8	8,000	1.8	8,000	1.8	8,000	1.8	
Group No. 9 ore	6,000	6.50	1,200	2.00	6,000	1.8	6,000	1.8	6,000	1.8	6,000	1.8	6,000	1.8	6,000	1.8	6,000	1.8	6,000	1.8	6,000	1.8	6,000	1.8	
Group No. 10 ore	4,000	6.50	800	2.00	4,000	1.8	4,000	1.8	4,000	1.8	4,000	1.8	4,000	1.8	4,000	1.8	4,000	1.8	4,000	1.8	4,000	1.8	4,000	1.8	
Group No. 11 ore	2,000	6.50	400	2.00	2,000	1.8	2,000	1.8	2,000	1.8	2,000	1.8	2,000	1.8	2,000	1.8	2,000	1.8	2,000	1.8	2,000	1.8	2,000	1.8	
Open hearth cinder	2,500	15.1	303.3	9.45	1,650	56.0	40	14.0	1,795.0	3.1	1,795.0	3.1	1,795.0	3.1	1,795.0	3.1	1,795.0	3.1	1,795.0	3.1	1,795.0	3.1	1,795.0	3.1	
Open hearth cinder	2,000	15.0	240.0	9.00	1,300	50.0	30	10.0	1,300.0	0.0	1,300.0	0.0	1,300.0	0.0	1,300.0	0.0	1,300.0	0.0	1,300.0	0.0	1,300.0	0.0	1,300.0	0.0	
Flue dust	700	8.50	59.5	3.70	3,000	21.6	5.0	3.5	50.20	35.1	9.00	63.0	.065	.45	1.0	7.0	19.07	13.1	4.0	1.32	12.1	1.32	1.07.0	1.07.0	
Roll scale	700	1.00	7.0	.10	1,000	7.0	.40	2.8	66.25	463.8	45	63.0	.065	.45	4.0	49	18.00	12.6	1.0	1.32	12.1	1.32	1.07.0	1.07.0	
Total No. 1.....	33,000	.....	2,461.4	.....	1,049.2	.....	866.2	.....	338.9	.....	15,514.0	.....	63.0	.....	39.8	.....	4,054	.....	6,698	.....	.....	.....	.....	.....
Coke	16,000	5.93	804.8	3,18	508.8	1.94	16.7	86.08	13,770.0	.923	3.7	2.3	368	.40	61	8.5	136	30	48.0	50	80.0
Total No. 2.....	.....	.....	3,266.2	.....	1,558.0	.....	866.2	.....	338.9	.....	15,539.7	.....	13,833.0	.....	43.5	.....	4,422	.....	6,762	.....	.....	.....	.....	.....
To pig iron.....	.....	.....	351.0	.....	.....	.....	866.2	.....	300.0	.....	.....	533.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Residue	.....	.....	2,915.2	.....	1,558.0	.....	.....	.....	38.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Limestone	7,200	2.95	212.4	1.00	72.0	53.20	3,830.0	.....	.....	.....	.....	.....	.....	.....	.....	1.5	108	.....	.....	.....	.....	.....	.....	.....
Total No. 3.....	.....	.....	3,127.6	.....	1,630.0	.....	4,696.2	.40	38.9	.....	15,539.7	.....	.....	.....	47.1	.....	4,530	.....	.....	.....	.....	.....	.....	.....
Estimated slag	9,620	32.51	3,127.6	16.94	1,630.0	48.71	4,696.2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Flue dust made	1,600	9.50	152.0	4.11	65.7	3.33	53.3	.56	8.9	55.80	892.7	10.00	160.0	.070	1.10	.....	.....	.....	.....	.....	.....	.....	.....	.....
Check No. 4.....	.....	.....	2,975.6	.....	1,564.3	.....	4,642.9	.....	30.0	.....	14,638.0	.....	.....	.....	46.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
True slag	9,340	31.85	2,975.6	16.74	1,564.3	49.70	4,642.9	.32	30.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Wind	68,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pig iron	15,620	1.95	165.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Gas	9,128.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

On account of the numerous chemical reactions involved it is necessary to compile an "elementary distribution" with the object in view of their final arrangement in the metal, slag, and gases. Taking each of the materials charged, their weight, and analysis, the Table No. 4 is obtained. Taking the silicon reduced from silica, the manganese reduced from the oxide, phosphorus, and sulphur, we get the arrangement in the metal, and the arrangement of the other substances in the slag and gases.

The starting point in the calculations is the hot blast, and in this test 32 deg. Fahr. is taken as the base point.

Hot Blast

A. Air in Engine Room and Stoves

HOT BLAST. AIR IN ENGINE ROOM AND STOVES		A. Air in Blowing Room.			
		\$	T°	Range	SM (o-t)
Air (dry).....	67,041	90°	58°	0.23421	B.t.u.
Moisture (sensible).....	959	90°	65°	25° 0.42597	10,212
Moisture (latent).....	959			B.t.u. per Pound	1,056,530
Total.....				1101.7	1,977,159
B. Air at entrance to stove, 200° F.					
Air (dry).....	67,041	200°	168°	0.23548	B.t.u.
Moisture (sensible).....	959	200°	65°	135° 0.43730	56,581
Moisture (latent).....	959			B.t.u./Pound	1,056,530
Total.....				1101.7	4,265,296
C. Air through Blast Furnace Stove.					
Hot blast on clean gas.....				1210° F.	
Hot blast on dirty gas.....				1110° F.	
Clean Gas.					
Air (dry).....	67,041	1210°	1178°	0.24715	B.t.u.
Moisture (latent).....	959			B.t.u. per Pound	1,056,530
Moisture (sensible).....	959	1210°	1178°	0.54133	611,554
Total.....					21,183,719
Dirty Gas.					
Air (dry).....	67,041	1110°	1078°	0.24600	B.t.u.
Moisture (latent).....	959			B.t.u. per Pound	1,056,530
Moisture (sensible).....	959	1110°	1078°	0.53103	548,931
Total.....					19,384,834

Heat Generated and Absorbed

D. Heat in Materials Charged.

Dry Material		\$	T°	Range	SM	B.t.u.
Mixed ores.....	28,946	70	38	0.14959	164,529	
Coke.....	15,632	70	38	0.24100	143,157	
Limestone.....	7,092	70	38	0.20860	56,217	
Water in above.....	4,530	70	38	1.00000	172,140	
Total.....					536,043	
From the "elementary distribution" we get the carbon actually burned and as follows:						
Carbon in flue dust charged.....					63.0	
Carbon in coke charged.....					13770.0	
Carbon absorbed by pig iron.....					533.0	
Carbon in flue dust made.....					160.0	
Total.....					13833.0	693.0
Carbon burned.....					13139.0	
Heat in carbon burned = 14,544 × 13,139 = 191,093,616 B.t.u.						

H. Heat in Gas Made.

From the "elementary distribution," or burden sheet, there is made 91,283 pounds of gas, containing 13,957 pounds of carbon in it. Analysis of gas made averaged 13.06 CO₂ and 25.70 CO, and keeping this ratio intact, namely 55% CO₂ to 45% CO₂ by volume, we get the following:

FROM BURDEN SHEET		AVERAGE FROM TESTS			
Gas	Pounds	% Weight	% Volume	% Weight	% Volume
CO ₂	17,260	18.91	12.50	13.06	19.83
CO.....	21,903	23.99	25.07	25.70	24.68
O ₂	254	0.278	0.25		
H ₂	187	0.204	2.97	3.69	25
H ₂ S.....	6	0.006	0.005		
N ₂	51,673	56.610	59.205	57.48	55.24
Total.....	91,283				
B.t.u. per # = 1187.5.....					1252.91
B.t.u. per cubic foot @ 32° = 97.82.....					102.53
Weight per cubic foot @ 32° = .08215.....					.08179
Cubic feet per pound = 12.14.....					12.22
Pounds		B.t.u./Pound		B.t.u.	
91,283		1187.5		108,398,562	Latent
91,283		393°	0.24580	8,817,938	Sensible
Moisture.....	4530#	425°	1115.8	5,714,142	
4530#		425°	S. P.	5,714,142	SM
4530#		425°	314°	0.463775	B.t.u./#
Total B.t.u. in the gas.....					122,930,642

TABLE No. 2

TABLE OF MISCELLANEOUS TEMPERATURES AND OTHER DATA REQUIRED FOR THE HEAT BALANCE

Tonnage of basic iron per day.....	445 tons
Number of charges per day (average).....	64
Temperature of air in blowing room.....	90° F.
Temperature of air at snort valve.....	200° F.
Temperature of hot blast on clean gas.....	1210° F.
Temperature of hot blast on dirty gas.....	1110° F.
Temperature of furnace top.....	425° F.
Temperature of B. F. gas at stove burner, dirty gas.....	280° F.
Temperature of B. F. gas at stove burner, clean gas.....	90° F.
Cu. ft. free air blown per minute, test.....	42,188 cu. ft., at 90°
Pounds of air blown during test.....	68,000
Hot blast pressure.....	15.7 pounds
Cooling water used, for 24 hours =.....	2,571,000 gallons
Average temperature difference in cooling water =.....	8° F.

HOT BLAST (CALCULATIONS)

Cubic feet of air blown per minute at 90° F.....	42188.	
Weight of air blown per cubic foot at 90° F.....		.07166#
Pounds of air blown during charge period.....		68000. #
Grains moisture per cubic foot air.....		7.1
Pounds of moisture blown in charge period.....		959. #
A. SM (o-t). 32° F. = base. 90 - 32 = 58° t-difference.		
Air N ₂ = 76.9 0.2405 + (58 × 0.0000119) = 0.24119.....		0.19547
O ₂ = 23.1 0.2104 + (58 × 0.0000104) = 0.21100.....		0.04874
SM (o-t).....		0.23421
Moisture = 7.1 grains per cubic foot. Saturation point = 65° F.		
65° F. = 18.2° C. 606.5 + 0.305 (18.2).....		= 612.05 Kg. cal.
		= 1101.7 B.t.u. per #
B. SM (o-t) N ₂ = 76.9 0.2405 + (168 × 0.0000119) = 0.24250.....		0.18648
O ₂ = 23.1 0.2104 + (168 × 0.0000104) = 0.21215.....		0.04900
SM (o-t).....		0.23548
Moisture S.P. 18.2° C. = 1101.7 B.t.u. per # latent.		
SM = 0.42 + 0.000103t° 0.42 + 0.000103t°		
= 0.42597 + 0.000103(58) = 0.43730		
C. Clean Gas.		
SM (o-t) = (32 - 1210°) t-difference = 1178° F.		
Air N ₂ = 76.9 0.2405 + (1178 × 0.0000119) = 0.25452.....		0.19572
O ₂ = 23.1 0.2104 + (1178 × 0.0000104) = 0.22265.....		0.05143
SM (o-t).....		0.24715
SM of Moisture = 0.42 + 0.000103t°		
= 0.42 + 0.000103(1178) = 0.54133		
Dirty Gas.		
Air N ₂ = 76.9 0.2405 + (1078 × 0.0000119) = 0.25333.....		0.19481
O ₂ = 23.1 0.2104 + (1078 × 0.0000104) = 0.22161.....		0.05119
SM (o-t).....		0.24600
SM of Moisture = 0.42 + 0.000103t°		
= 0.42 + 0.000103(1078) = 0.53103		

and Absorbed

E. Heat Absorbed in Reduction.			
Material	Pounds	B.t.u. per #	B.t.u.
Silicon.....	165	11,571	1,909,215
Manganese.....	232	4,100	951,200
Iron.....	14,638	3,143	46,007,234
Phosphorus.....	46	10,605	487,830
Liberation of CO ₂	2,999	1,710	5,128,290
Dissociation of H ₂ O.....	950	5,740	5,504,660
Total.....			59,988,429
F. Total Heat in Metal, Slag and Flue Dust.			
Material	Pounds	B.t.u. per #	B.t.u.
Basic metal.....	15,620	450	7,029,000
Slag.....	9,340	692	6,463,280
Flue dust.....	1,600	130	208,000
Total.....			13,700,280
G. Heat Carried Off in Cooling Water.			
333,350 × 8 = 2,668,400 B.t.u.			
H. Calculations.			
Gas	% Weight	Standard Weight	% Volume
CO ₂	18.91	0.12424	15.22
CO.....	23.99	0.07858	30.52
O ₂.....	.278	0.08953	.31
H ₂.....	.204	0.00565	3.62
H ₂ S.....	.006	0.00642	.006
N ₂	56.610	0.07859	72.03
			59.205
			.04653
Average from Tests.			.082155
			97.82
Gas	% Volume	Standard Weight	% Weight
CO ₂	13.06	0.12424	1.622
CO.....	25.70	0.07858	2.019
H ₂	3.69	0.00565	.021
N ₂	57.48	0.07859	4.517
			55.24
			.04517
SM of Gas.			.08179
			102.53
CO ₂	18.91	0.1900 + 393 × 0.00006	0.21358
CO.....	23.99	0.2405 + 393 × 0.0000119	0.24517
O ₂.....	.278	0.2104 + 393 × 0.0000104	0.21448
H ₂ & H ₂ S.....	.210	3.3700 + 393 × 0.000170	3.43681
N ₂	56.610	0.2405 + 393 × 0.0000119	0.24517
SM.....			0.24580
91,283# Dry Gas @ .08215 # per cubic foot.....			1,111,174 cu. ft.

Hot Blast Stoves

Two cases of use of the gas now present themselves: Cleaned or Dirty Gas used in Blast Furnace Stoves. The following data was taken from stoves, and in which operation 3 stoves are continually used on gas, and 1 stove on air.

	Cleaned Gas	Dirty Gas
Pounds of gas per charge	24,100	26,500
Temperature at burner	90°	280°
Grains of moisture per cu. ft.	14.2	28.5
Saturation point	90° F.	111° F.
Pounds of moisture in gas	595.	1313.

J. Heat in Gas Burned in Stoves.

Cleaned Gas.	B.t.u./#	B.t.u.
#	1187.5	28,618,750
24,100		
Moisture		
595		
S.P. = 90, hence no superheat		

Dirty Gas.	B.t.u./#	B.t.u.
#	1187.5	31,468,750
26,500		
Moisture		
1313		
1313		

Clean Gas	Dirty Gas
29,254,261	32,985,537

Blowing

The following facts were observed in connection with the Blowing Engines, Boilers, and other auxiliaries in connection with the Blast Furnace Plant:

A. Gas Blower required 8775# of gas to blow the air required per charge period.

A. Gas Electric Set required 15# of gas per KWH.
It required 1.7# of Dirty Gas to evaporate 1# of steam at 140#.
It required 1.6# of Clean Gas to evaporate 1# of steam at 140#.
Steam Blowing Engines consumed 25,000# of steam per charge period to blow the air required as found from water rate figured from indicator cards.

Dirty Gas	Pounds Dry Gas	B.t.u.
Out of furnace top	91,283	122,930,642
Leakage and bleeding, 10%	9,128	12,293,064
To stoves, dirty gas	26,500	32,985,537
Remaining to boilers	55,655	77,652,041
Steam generated, pounds	32,740	39,091,560

Blowing engines	25,000	29,850,000
Steam pumps	5,000	5,970,000
Water pumps	500	597,000
Hoists	2,000	2,388,000

Total	32,500	38,805,000
Surplus	240	280,560

Steam at 140# gage has 1194 B.t.u. total heat per #.
The above condition is a Steam Blown Blast Furnace with all auxiliaries using steam, and it may be noted that there is practically use for all the steam generated at the furnace itself.

Cleaned Gas	Pounds Dry Gas	B.t.u.
Out of furnace top	91,283	122,930,642
Leakage and bleeding, 10%	9,128	12,293,064
To clean gas at cleaners	82,155	99,794,411
Loss of heat in cooling		10,843,167
To stoves	24,100	29,254,261
Remaining	58,055	70,540,150
Steam generated	44,660	53,324,040
Blowing engines	25,000	29,850,000
Steam pumps	5,000	5,970,000
Water pumps	500	597,000
Hoists	2,000	2,388,000

Total	32,500	38,805,000
Surplus	12,160	14,519,040

# of Gas	B.t.u./#	Total
82,155	1187.5	97,559,062
2,029# H ₂ O	1101.7	2,235,349
Total		99,794,411

Steam generated = 58,055# of gas ÷ 1.3 = 44,660#

Cleaned Gas	Pounds Dry Gas	B.t.u.
Out of furnace top	91,283	122,930,642
Leakage and bleeding, 10%	9,128	12,293,064
Cleaned gas through cleaners	82,155	99,794,411
Loss of heat in cleaning		10,843,167
To stoves	24,100	29,254,261
Remaining	58,055	70,540,150
Gas blowers for furnace	8,775	10,644,075
Auxiliaries take 3000# steam =	4,800 gas	5,822,400
Electrical use	44,480 gas	54,073,675

44,480# gas =	KWH. 2,965	B.t.u. 3412	10,116,580
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It was stated that the furnace tested was one rated at 600 tons of pig iron per day. During the week in which these simultaneous observations were taken 445 tons of pig iron were made per day, this being basic pig iron, and which is a fair figure for such practice. It was not desirable to make any unnecessary assumptions in the conditions, and accordingly the facts were taken as they were observed.

H. Calculations.

4,530# Moisture @ 7000 grains per lb. = 31,710,000 grains
Grains moisture per cubic foot @ 32° = 28.5

Saturation point = 111° F. = 44° C.

SM (o-t) = 0.42 + 0.000103t°
B.t.u. = 606.5 + 0.305(44) = 619.92 Kg. Cal.
= 1115.8 B.t.u.

SM = 0.42 + 0.000103(425)
= 0.42 + 0.043775
= 0.463775

SM (o-t). T = 280° - 32 = 248.

CO ₂	18.91	0.1900 + 248 × 0.00006	0.20488	0.03874
CO	23.90	0.2405 + 248 × 0.0000119	0.24345	0.05840
O ₂	278	0.2104 + 248 × 0.0000104	0.21298	0.00059
H ₂ & H ₂ S	210	0.3700 + 248 × 0.0000170	0.37421	0.00708
N ₂	56.610	0.2405 + 248 × 0.0000119	0.24345	0.13782

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Conclusion

	HEAT BALANCE STEAM BLOWN FURNACE WITH DIRTY GAS		STEAM BLOWN FURNACE WITH CLEANED GAS	
	A.	B.	A.	B.
Air in blowing room.....	1,977,159	.94	1,977,159	.92
Air at entrance to stoves.....	4,265,296	2.02	4,265,296	2.00
Air through stoves.....	19,384,834	9.18	21,183,719	9.95
Heat in materials charged.....	536,043	.25	536,043	.25
Heat in carbon burned.....	191,093,616	90.57	191,093,616	89.80
Total.....	211,014,493	100	212,813,378	100
Heat of reduction.....	59,988,429	28.44	59,988,429	28.19
Heat in slag, metal and flue dust.....	13,700,280	6.49	13,700,280	6.43
Heat in cooling water.....	2,668,400	1.26	2,668,400	1.25
Heat in gas made.....	122,930,642	58.26	122,930,642	57.78
Total.....	199,287,751	94.45	199,287,751	93.65
Loss due to radiation, etc.....	11,726,742	5.55	13,525,627	6.35
Loss to cooling of gas.....	12,293,064	5.82	10,843,167	5.09
Loss due to gas leakage.....	32,985,537	15.63	29,254,261	13.74
Gas to stoves.....	77,652,041	36.81	70,540,150	33.14
Gas to boilers.....	39,091,560	18.52	53,324,040	25.05
Heat in steam made.....	29,850,000	14.14	29,850,000	14.02
Heat in compression of air.....	2,288,137	1.08	2,288,137	1.08
Heat in steam to auxiliaries.....	8,955,000	4.24	8,955,000	4.20
Heat in surplus steam.....	286,560	.14	14,519,040	6.82
GAS BLOWN FURNACE, CLEANED GAS				
C.				
Air in blowing room.....	1,977,159	.92		
Air at entrance to stoves.....	4,265,296	2.00		
Air through stoves.....	21,183,719	9.95		
Heat in materials charged.....	536,043	.25		
Heat in carbon burned.....	191,093,616	89.80		
Total heat.....		212,813,378	100	
Heat of reduction.....		59,988,429	28.19	
Heat in slag, metal and flue dust.....		13,700,280	6.43	
Heat in cooling water.....		2,668,400	1.25	
Heat in gas made.....		122,930,642	57.78	
Total.....		199,287,751	93.65	
Loss due to radiation, etc.....		13,525,627	6.35	
Loss due to gas leakage.....		12,293,064	5.77	
Loss to cooling of gas.....		10,843,167	5.09	
Gas to stoves.....		29,254,261	13.74	
To gas blowers.....		10,644,075	5.00	
To auxiliaries.....		5,822,400	2.73	
To electrical units.....		54,073,675	25.41	
Converted into electricity.....		10,116,580	4.75	
Efficiency of Blowing Engines.				
Air Blown.....	67,041	Heat Delivered.....	2,288,137	Efficiency, %.....
Gas blowers.....	67,041	10,644,075	2,288,137	7.66
Efficiency of Stoves.				
Heat in Air Entering.....	4,265,296	Gas Burned.....	21,183,719	Efficiency, %.....
Dirty gas.....	4,265,296	32,985,537	19,384,834	57.8
Conclusion.				
A. B. C.				
Work of reduction, melting and hot blast.....	43.17%	43.65	43.65	
Work of cooling furnace.....	1.26%	1.25	1.25	
Radiation loss.....	5.55	6.35	6.35	
Gas leakage loss.....	5.82	5.77	5.77	
Loss of heat in stoves.....	8.47	5.79	5.79	
Loss of heat in boilers.....	18.29	18.09	18.09	
Loss of heat in cooling gas.....	18.52	5.09	5.09	
Heat in steam made.....	18.38	25.05	25.05	
Steam used by furnace.....	18.38	18.22	18.22	
Steam heat salable.....	.14	6.82	6.82	
Heat in gas cleaned and used in blowers.....			5.00	
Heat in gas cleaned and used in auxiliaries.....			2.73	
Heat in gas to electric units.....			25.41	
Conversion of available gas into electricity.....			4.75	

connection with steam blowing engines or with gas blowing engines and generator sets.

In the conclusion it may be noted that the stove efficiency on clean gas is 57.8 per cent and on dirty gas 45.9 per cent. The stoves themselves are open to much discussion, and the relative economy of two or three-pass stoves is an open question. The ratio of checker work is absurd when comparisons are made, and the relative value of side or central combustion chamber type of stoves has not been settled.

It seems that there is a very fertile field for effecting important improvement, and the figuring of heat balances under representative conditions should settle these points:

In all applications of new apparatus or remodeling of old, it is necessary to consider investment with the economy effected.

The regular operation obtained by using the dry blast is an example of a large investment required to effect large savings.

Notes on Tube-Milling in All-Slime Cyanide Practice

BY W. J. PENTLAND

There seems to have been a general agreement among writers on the subject of tube-milling for cyanidation that the most desirable moisture content of the pulp is 38 (and sixteen decimals) per cent. It is true that many accounts have been published that seem to demonstrate this figure the ideal one. It is true also, we believe, that almost all of the tube-mills used in the experiments on correct moisture content were of the trunnion, small-discharge-opening type. Many of the early ideas on tube-milling no longer hold good. For example, it used to be said that "the finer the feed going to the tube-mill, the greater amount of net fine grinding done," and "the longer the pulp can be kept in the mill, the finer it will be ground." Many such comments were considered sound once, but are no longer heard. We believe it not improbable, therefore, that the old standard of 38 (and so many decimals) per cent moisture may go the way of some other assumptions. We now find many operators specifying 35 per cent moisture as preferable; to-morrow they will be saying 33 per cent, and may some time hold to 30 per cent.

Individual experiments are helpful, but they are not conclusive. Experimental conditions are rarely realized in practice. We endeavor to have practical conditions in our experiments, but rarely get them. Then we are apt to persuade ourselves that in subsequent practice we have the conditions of the experiments. Further, design of machinery and methods of operation change from time to time, and the standards of one period become untenable as practice in an art progresses. Thus, all early tube-mills were of the trunnion type; then came the tire type, with large discharge opening; and now we witness the Chalmers & Williams idea of inserting lifters behind perforated liner plates at the discharge end of the tube, virtually giving a discharge area of the whole diameter of the tube-mill.

In determining proper tube-milling conditions, it is one thing to have a single tube in a plant and be able to vary the system with facility, and quite another to have ten, twelve or fourteen tubes without equal facility in varying conditions. In the latter case it is usually necessary to decide upon a system and then carry it out over a period of a month or more and judge the average results. We believe that this method is likely to give more reliable information, as the experiment is subject to true working conditions.

It is usually true that a pulp must contain 38 per cent moisture in order to "get it through" the tube, or to "make the tube handle it," but not necessarily grind it to the required degree of fineness. Under such conditions we discharge the pulp to a classifier so that the unground portion may be returned to the tube-mill, and this is done because more work is demanded of the tube-mill than it can do under the conditions prescribed. In this respect the tube-mill is to be compared to a launder transporting pulp. If it is set practically level, as in the small-discharge-opening type, the more ore it has to handle, the more moisture must be supplied to transport the ore. The greater the inclination, or difference in fall between feed and discharge, the more ore can be passed as a thick pulp, or, in other words, the percentage of moisture required to carry it can be reduced.

Duty of the Tube-Mill

It is a perfectly legitimate subject for debate whether the load going to the tube-mill should be in excess of the tube's capacity for grinding to the requisite degree of fineness, necessitating the return of a part of the pulp for regrinding, or be so adjusted that all of the

required grinding is done in one passage of the pulp through the tube. If we are depending on the tube-mill to act as part of the agitation system, we may be compelled to return part of the pulp, but there are more economical agitators than tube-mills. If we can obtain proper grinding with one passage of the pulp through the tube, and also secure some agitation and dissolution of metal at the same time, we can well afford to build the subsequent agitators a little larger to secure dissolution of the metal that would have taken place in the tube-mill if we had returned part of the pulp to it.

The use of a closed circuit in tube-milling has become general practice, and this feature is closely related to the custom of grinding in 38 per cent moisture, for under no conditions will pulp of that moisture content pass through a tube-mill and be properly ground for all-sliming. At the same time we believe that there is no fixed and unalterable reason for returning part of the pulp to the tube-mill. It is the custom; just as it is custom, also, to use 38 per cent moisture. The advocates of this practice claim that if thicker pulp be fed to a tube-mill the machine will become "constipated" and will be unable to handle sufficient tonnage, and so for mechanical reasons it is necessary that the pulp be more dilute. As a matter of fact, this claim tells us exactly what is the matter with tube-mills of small discharge openings. It is admitted that such mills will not grind a sufficient tonnage of low-moisture pulp, and so we dilute it and circulate it through and through the mill until it is sufficiently ground.

An Experiment with Graded Pulps

A simple experiment can be performed that will give some light on what takes place in a tube-mill. Take battery sand practically free from slime as it comes from the discharge of a classifier, and screen it into a number of sizes at intervals of 10 points between 10-mesh and 150-mesh. With each size make a pulp containing 38 per cent moisture, and by agitation of some kind keep the solids in suspension so that the pulp shall be of uniform consistency throughout. Then, commencing with the coarsest grade, take a sample of each pulp on a spatula. A certain quantity of the coarsest grade can be raised and retained on the spatula. Of the succeeding sizes less and less can be raised until, in the case of the 150-mesh pulp, scarcely any can be secured because the accompanying moisture affords sufficient carrying medium to keep the solids in suspension. Or, if each of the pulps were to be dumped on a flat surface, we would find that almost all of the coarsest grade would remain on the plate. There would be successively smaller quantities of the finer grades, and as we approached 150-mesh we would find more and more of the ore carried away in suspension, even with 38 per cent moisture.

We believe that this experiment indicates what occurs in a tube-mill. With the same percentage of moisture, finer sizes of sand are kept in suspension among the pebbles; and even though the whole mass of pebbles and pulp be rolling and grinding, the finer sands are still in suspension and sluicing around in the voids. The coarser sands are picked up by the pebbles and remain on their surfaces because the accompanying moisture is not sufficient to keep them in suspension. They are then in favorable position to be caught between pebbles and receive the requisite amount of grinding. We think that the pulp should be thick enough to permit the sand particles to cling to the pebbles as they rise with the mill. When the pulp is so thin that no particles cling to the pebbles, poor work is being done, and only the coarse sand is being satisfactorily ground.

It is readily seen that such thick pulp will not flow through a tube-mill that has feed and discharge open-

ings at practically the same level; but it will flow when the discharge is lower than the feed, according to the difference in levels. Tube-mills of small discharge opening were responsible for the standard of 38 per cent moisture; and, in turn, adherence to that standard is responsible for the present tendency toward shortening tube-mills, from 20 feet and more, to 16 feet. With 38 per cent moisture it is only of the coarser sands that the due proportion is ground, and that grinding takes place near the feed end of the mill. Then the remaining length of a long tube gives little service as a grinder and acts mainly as an agitator; therefore we shorten the tube, classify the ground pulp and return the oversize in the hope that it also will be duly ground in its next passage through the mill.

Diameter is an important factor in tube-mill design, but it is not "the whole thing," and increased diameter has the disadvantage of requiring more power for starting the mill. There is a tendency at present to regard sixteen feet as the most desirable length, on the assumption that practically no grinding is done beyond this point, making additional length useless. Some operators are inclined to believe that this is a mistaken idea, and that with thick pulps, or low moisture content, and a low discharge level, longer mills can be made to do satisfactory work. There is an advantage in using large units, but there is a limit to the practicable diameter, and greater capacity can then be had only by increasing the length.

Cones Versus Drag Classifiers

At one time it was customary to use cones for thickening tube-mill feed; but these devices gave trouble from the beginning, and only by unremitting care and attention could they be made to furnish pulp even as thick as 38 per cent moisture. We believe, however, that as drag classifiers displace cones, and operators have thicker pulps to experiment with, they will regard them as more desirable. As tire-type mills come into greater use, the advantage of quicker discharge will be observed; and those who have condemned the long tube-mills will try discharging with the lifter device over the whole diameter of the tube, and will find that the long mills will grind a larger tonnage than the shorter ones.

Fresh battery sand is easier to grind to slime than is returned sand that passed through the tube-mill and classifier. The former is sharp and angular; the latter is rounded. The former can be more readily dewatered than the latter, and will be more readily picked up by the pebbles in the mill. This can be demonstrated practically by comparing the work of tube-mills on sand from old tailing dumps and fresh battery sand from the same ore.

Effect of Size of Feed on Capacity

It has been observed that some operators deceive themselves as to the net work their tube-mills are doing. If they are treating 100 tons of ore per day, and the pulp going to the treatment vats contains 80 per cent minus 200-mesh, they assume that the tube-mills are grinding 80 tons per day, forgetting that with 16-mesh screens on the battery some 38 to 40 tons was already ground to 200-mesh before passing to the tubes, so that the latter are really grinding but 40 to 42 tons to the required mesh. In this connection we recall a neighboring operator who had 14 tube-mills under his direction, and had always estimated their work at 40 odd tons daily. On properly revising his estimates he found the figure reduced to about 28 tons daily. Feeling that the tube-mills were not doing as much as they should, he endeavored to improve the service. By loading the mills with additional pebbles, feeding the thickest pulp his

launders would carry, and substituting 6-mesh screens on the batteries for 16-mesh, he brought the tonnage up from 650 to 1000 tons daily and still had 80 per cent minus 200-mesh solids in his final pulp. This mill follows the practice of open circuit; the pulp does not return to classifiers after passing through the tubes, but flows through a revolving trommel that removes any coarse sand that may accidentally occur in the pulp. The trommel has a 16-mesh screen.

A personal experience may be cited. We had 200 stamps, cone classifiers and thickeners, two tube-mills 5 ft. by 30 ft. and seven tube-mills 4 ft. by 22 ft. The ground pulp was again classified in cones. Following the dictum that the finer the sand going to the tubes the better the product, we used 35 and 40-mesh screens on the batteries, yielding a product containing about 60 per cent minus 200-mesh solids. From 730 to 750 tons could be treated, giving a final pulp of 80 per cent minus 200-mesh. By substituting 25-mesh screens on 100 stamps and 30 or 35-mesh on the other hundred, we were enabled to raise the tonnage to from 830 to 850 tons, but this was the most we could get through the tube-mills. With cone thickeners we had to give constant attention to keep the moisture down to 38 per cent.

We then hung up 100 stamps, put 8 and 10-mesh screens on the remaining hundred, rearranged and improved the cone system of classification and thickening, and added three tube-mills 5 ft. by 24 ft. This system enabled us to increase capacity to 1050 tons daily; while battery, crusher and conveyor costs that used to total 35 cents went down to 17 cents.

Some of the tube-mills received battery pulp only; others received a mixture of battery pulp and oversize returned from classifiers; and still others received only return feed. The last was itself classified or graded by the arrangement of the distributing box at the top of the elevator, so that some mills received fine returned sand and others coarse. We had continuous opportunity to observe the difference in grinding various sizes of sand. Coarse sand dewaterers easily and grinds better in the tube-mill; fine sand is difficult to dewater in cones, and is harder to grind. With coarse feeds we could get lower moisture, greater tonnage and better ground pulp; with the finer feeds it was almost impossible to get low moisture, the tonnage was reduced, and the product never contained as much minus 200-mesh solids as was secured from the coarser feeds.

Grinding Oxidized and Sulphide Ores

Our mill ore consisted of 950 tons of yellow, oxidized ore, assaying about \$7 per ton, and 100 tons of blue, sulphide ore, assaying about \$30 per ton. There was never much difference between the mine and mill superintendents regarding the tonnage or value of the yellow ore; but there was a continual difference between them as to the blue ore, as this factor entered strongly into the calculations at the end of the month. So we can safely assume that the figures for tonnage of blue ore, as agreed upon by the superintendents and given herewith, are correct.

Formerly the two classes of ore were mixed in the main bin, but on account of the more refractory character of the blue ore it was decided to give each separate treatment.¹ Ten stamps were set aside for blue ore, and a special bin provided. Separate classifying and thickening cones also were added. Later a drag classifier was substituted for the cones. The tube-mill was 4 ft.

by 22 ft. and had a discharge opening about 18 inches in diameter, being of the tire type.

Extensive experiments were conducted on kind and size of pebble load, and on moisture content of pulp, each experiment being under way for a number of days with the regular attendants on shift. Battery screens were 7, 8, 10 or 12-mesh and were varied to give the desired tonnages under different conditions.

With iron pebbles or grinders, cast-iron ovals or old bolts cut into five-inch lengths, it was possible to grind 120 tons of blue ore daily and get a final pulp containing from 86 to 88 per cent minus 200-mesh. The moisture was carried as low as 25 per cent, though at this consistency the pulp was really too thick to work through the mill, and only about 100 tons could be handled. At 28 to 29 per cent moisture, however, 120 tons could be treated—that is, a total of 120 tons through stamps and tube-mill. From 30 to 35 per cent minus 200-mesh solids was produced in the batteries, leaving only about 70 tons actually ground to minus 200-mesh in the tube-mill. The power requirement under these conditions was about 95 hp., and as only a 75-hp. motor was available, a run of a few days only was possible.

With a mixture of iron grinders and imported pebbles, or using mine rock for pebbles, the horse-power was reduced to 80 or 85, and the total tonnage treated to 100, still obtaining a final pulp with over 85 per cent minus 200-mesh solids.

The final conclusion was to treat 80 to 85 tons of blue ore daily, using mainly mine rock for grinders, with a small daily addition of imported pebbles. The moisture was maintained at 31 to 32 per cent.

Summary and Comparison of Results

While using 200 stamps with 25 and 35-mesh screens on the batteries, from 50 to 55 per cent of the battery pulp was minus 200-mesh, and the final tube-mill pulp contained 80 per cent minus 200-mesh. Under these conditions each of nine tube-mills ground on an average 25 tons to minus 200-mesh. Since using only 100 stamps, with 8 to 10-mesh screen on the batteries, giving a battery pulp containing only 30 to 33 per cent minus 200-mesh, each of twelve tube-mills averages 42 tons net. Drag classifiers have now been installed throughout the mill and the cones are on the scrap heap, as also is 38 (and so many decimals) per cent moisture for tube-mill feed.

Of these tube-mills, four were trunnion type with small discharge openings; eight were tire type with about 18-in. discharge openings. There were two pairs of 4 ft. by 22 ft. tubes, each pair comprising one trunnion type and one tire type. There was one pair of trunnion type only. The remaining mills, two 5 ft. by 30 ft., and one 4 ft. by 22 ft., all were of tire type with 18-in. discharge openings. With the first two pairs mentioned, it was quite convenient to compare the work of each type, and it was observed that the trunnion type never gave as good results in either quantity or quality as did the tire type.

Effect of Speed in Grinding

Grinding in tube-mills is done by the pebbles sliding or rubbing over or against one another, and not by falling against each other. Very little grinding is done between pebbles and the tube-mill liner. The revolution of the mill should be so regulated that centrifugal force will raise the load high enough to permit the pebbles to slide over each other, but it should never be sufficient to permit the pebbles to fall through clear space. The proper mean speed probably results in letting some of the upper pebbles fall clear while the main body slides. This result can be obtained better through cen-

¹This blue pulp was agitated separately and then combined with the yellow, receiving also the agitation considered necessary for the latter. This method of treatment is an example of the practice which I suggested in a former article in this journal, October, 1914, page 621, wherein I proposed giving the most refractory part of an ore its due treatment apart from the rest, instead of subjecting the whole ore to the treatment necessary for only a small portion of it.

trifugal force than by liners adapted to carry the whole load up.

Irregular-shaped mine rock used for grinding probably does little work until it has been ground to round or oval shape, and tube-mill power for this purpose is expensive. The same amount of power expended on grinding with round pebbles would accomplish much useful work. Feeding pebbles through the scoop is slow work, and pebbles that miss the scoop and fall in the feed-box may cause the breaking of the scoop. On removing the door of a tube-mill we usually find the pebbles evenly arranged throughout the mill, according to size, regardless of the method of feeding them.

When a tube-mill is grinding its full load a distinct rise in temperature of the shell can be noted. If the pebble load is light, or the moisture content of the pulp so high that the increased temperature is not apparent, the mill is not doing the work it can be made to do.

Relining a Tube-Mill

With El Oro liners a tube-mill can be relined in 14 to 16 hours. The new liners should be piled near the tube on the previous day. At 5 a. m. stop the mill, take off the man-hole plates and start the mill again, allowing the pebbles to discharge on the floor, then stop the mill again, loosen the bolts holding the liners, taking the nuts off and driving the bolts to the inside, where they are gathered up. Now start the mill again, and inside of half an hour the plates will have fallen and almost all of them will be lying on the floor beneath the mill. The new plates and pebbles can be replaced, and the mill be in operation again by 8 p. m.

Denver, Colo.

Copper in Babbitt Metal

BY E. W. HAGMAIER

Babbitt metals contain copper in varying amounts from several per cent to a trace. While copper is not the most difficult metal to determine in the alloy, still the steps necessary to obtain the copper in suitable form are somewhat tedious.

The writer has met with very good success by using the following scheme.

Place 1 gram of the filings or sawings in a 250-c.c. beaker, add 15 c.c. of hot water, and sufficient tartaric acid to hold all the tin and antimony in solution, run in 5 c.c. of nitric acid from a pipette and boil until the alloy is all dissolved. If the solution is milky in appearance, there has not been sufficient tartaric acid added, and the determination must be started over, with more tartaric acid. When solution is complete remove the beaker from the plate, cool, and add 5 c.c. of sulphuric acid, place on the plate and boil until all the nitric acid is driven off. This can be determined when no more brown fumes are expelled. This will require about five minutes boiling. As soon as the nitric acid is driven off remove from the plate or the tartaric acid will char. Cool, add 50 c.c. of water, allow the lead sulphate to settle and filter, washing with 2 per cent sulphuric acid solution. Several washings can be made by decantation before transferring the bulk of the precipitate to the paper. This precipitate can be used to determine the lead by dissolving off the paper with ammonium acetate and acetic acid and precipitating the lead as chromate. The filtrate from the lead sulphate is made up to 400-500 c.c., 1 or 2 c.c. of hydrochloric acid added, a strip of copper free aluminium added, and the beaker placed on the back of the plate, and the copper will be thrown out. With careful manipulation all of the copper can be thrown out in this way after which it can be filtered off and determined electrolytically or by titration.

Babcock-Hagmaier Laboratories,
Lackawanna, N. Y.

Report of the Chemical and Dyestuff Committee of the New York Section of the American Chemical Society

At the meeting of the New York section of the American Chemical Society on Nov. 6 the Chemical and Dyestuff Committee, appointed at the preceding meeting, made its formal report.

The report was presented by the committee's chairman, Dr. BERNHARD C. HESSE, the other members of the committee being Messrs. J. B. F. HERRESHOFF, H. A. METZ, I. F. STONE, D. W. JAYNE, J. MERRITT MATTHEWS and ALLEN ROGERS.

On motion of Mr. Thomas J. Parker, the report was unanimously adopted. In the discussion Dr. L. H. Baekeland pointed out that time is needed to bring about an extension of the American chemical industries and that the success of an American coal-tar industry required the creation of a home market for its by-products.

In view of the authoritative character of the report we herewith give it in full:

Committee's Report

To the New York Section, American Chemical Society:

At the meeting on Oct. 9, 1914, the chairman of this section was authorized to appoint a committee to investigate into the feasibility of expanding the chemical and dyestuff industry in the United States and to report to this section on Nov. 6, 1914.

The undersigned committee was appointed Oct. 15 and at once proceeded. It addressed letters of invitation to co-operate to those who have been most active in the public prints in urging expanding of the chemical, and particularly the dyestuff, industry in the United States; further, an invitation was extended to the maker of the motion, which resulted in the appointment of this committee. The assistance from these is nil.

A request was addressed to trade publications in the city of New York and to some of the metropolitan dailies; in all nine such publications were requested to publish a suggested notice for the purpose of inviting co-operation; the object of this committee was set forth and request was made that suggestions be mailed to the chairman of this committee. All but one of these publications have complied with that request. No help has been obtained by this committee from any suggestions mailed to it as a result of this publicity.

Your committee has carefully considered all the public suggestions as to methods of improvement and has searched through the governmental regulations of the belligerent nations as to embargo and as to contraband of war, in order to construct therefrom a list of chemicals, inclusive of dyestuffs, which have thereby been shut off from the United States, in the hope of thus being placed in a position to make specific recommendations of value.

General Conditions of American Chemical Industries

It can be fairly stated that, in general, the chemical industry of this country is efficiently exploited and is making full use of all the opportunities presented to it under the normal conditions existing prior to the state of hostilities. Some of the chemicals which are imported from abroad are made in considerable amounts in this country as well, and the amount imported under normal conditions depends upon the ordinary normal fluctuations of business conditions both here and abroad. With the stoppage of this foreign supply the domestic production was not at once capable of making up the deficiency, but in a number of instances the American manufacturers have taken steps to increase their capac-

ity, and the strain in the market of those particular things will exist no longer than it will require to extend the manufacturing facilities to the proper extent.

Among these are ammonia salts, barium chloride, barium nitrate, bleaching powder, sodium cyanide, yellow prussiate, sodium nitrite, sodium hydrosulfite, zinc dust.

If, however, it be desired and if public necessity requires the introduction of the manufacture of explosives and further chemicals and dyestuffs into our home industry, such as *coal-tar product explosives, pharmaceuticals, medicinals and other intermediates and finished coal-tar dyes*, then alterations of our tariff law are inevitable, and the consumers in the first place and the public in general must share in the burden thus imposed. If conditions of national defense in case of attack by a foreign power require us to manufacture our own explosives, and to be in that regard independent of all foreign nations at all times, or if our textile industries or any other of our industries requiring coal-tar chemicals, such as dyestuffs, shall forever be protected and made independent of foreign nations for the supply of those materials, then the nation as a whole must bear the burden incident to such expansion. Under existing circumstances private enterprise and private capital have gone their limit. They have reached the limit for two reasons:

I. The explosive, dye and similar industries abroad, just referred to, are in a state of high development and of refined organization, and are financially the best suited to carry on an offensive campaign against any nation attempting to take business away from them.

II. Domestic manufacturers are prohibited by law from making use of co-operative commercial devices, such as pools, trusts, manufacturing and selling agreements and the like, whereas such devices are wholly lawful abroad, and are encouraged by the respective governments. In other words, the American chemical industry is expected to cope with the foreign industry while both its own arms are tied behind its back and its opponents have full and free use of their arms.

An Anti-Dumping Clause Required

The remedies required would be an effective anti-dumping clause that would certainly prevent underselling of domestic manufacturers in the United States by unfair methods. What the form of such clause shall be is a problem with which your committee is unable to cope; it is strictly a law-making and law-enforcing problem, and is allied to the usual problem of determining undervaluation as heretofore carried on by our Treasury Department; it, however, is a much more refined problem than the older problem of proving undervaluation. Nevertheless, your committee believes that with such a mechanism in our law that much would be done toward encouraging our chemical industries.

Change in Tariff Law Required

According to the best information that your committee can gather, such an anti-dumping clause alone would not be sufficient, however, to create complete and independent domestic coal-tar explosives, dyestuffs and medicinals industries. It has been conclusively demonstrated during the past thirty years that the present tariff rate of 30 per cent on dyestuffs is not sufficient to induce the domestic dyestuff industry to expand at a rate comparable with the consumption of dyestuffs in this country, and that therefore all dyestuffs made from coal tar, whether they be aniline dyes or alizarin, or alizarin dyes, or anthracene dyes or indigo, so long as they are made in whole or in part from products of or obtainable from coal tar, should all be assessed alike, namely, 30 per cent ad valorem plus 7½ cents per pound

specific, and that all manufactured products of or obtainable from coal tar, themselves not dyes or colors and not medicinal, shall be taxed 15 per cent ad valorem and 3¼ cents per pound specific.

The best information and judgment your committee can obtain is that the above manufactured products of coal tar, not dyes and not colors and not medicinal, should carry one-half the duty of the finished coal-tar dye and that the above rate of 30 per cent ad valorem and 7½ cents specific would probably be sufficient to encourage and enable domestic manufacturers to expand their operations to such an extent as to supply a very material increase in, if not the whole, of these commodities consumed in this country.

The reason for a specific duty is to protect the domestic manufacturer in the manufacture of the relatively cheap dyes, such as the cheap scarlets, the cheap yellows and the like, whose prices abroad are in the neighborhood of from 12 cents to 20 cents per pound, with dyes of that type 30 per cent ad valorem would not offer so serious an obstacle to importation and underselling thereof as does the 7½ cents per pound specific; on the other hand, on dyes whose prices are \$1 and upward per pound the function of the 7½ cents specific more nearly approaches zero. That is, with the cheap dyes the chief function lies in the specific portion of the duty, and with the expensive dyes the chief function lies with the ad valorem portion of the duty.

This is said to be the price the nation will have to pay to have a complete self-contained and independent coal-tar chemical industry. However, it must be remembered that if such an industry be created and importation of coal-tar products, inclusive of intermediates and dyes, is restricted, its ultimate effect upon the Federal revenues will have to be considered. It will, therefore, be necessary to determine carefully if the advantages to be gained are equal to the price to be paid.

No Compulsory Working Clause Required

This committee is a unit in the belief that an alteration of our patent laws aiming at compulsory working or compulsory licensing would not be any substantial benefit to this industry or to the country as a whole. Twenty-nine countries have attempted compulsory licensing clauses and fifty-six countries have attempted compulsory working clauses, and the best information your committee can obtain is that in none of these attempts has there been any appreciable measure of success. While it may be true that under extraordinary conditions, such as now exist, compulsory licensing might have some advantage, yet it is equally true that in normal times the disadvantage due to compulsory licensing or compulsory working would more than overbalance any advantage at all likely to be obtained under stress of unusual conditions.

In none of the countries where there have been working or licensing clauses, or both, co-extensive with the existence of the coal-tar chemical industry has there been established any real coal-tar chemical industry and your committee does not feel that an alteration in our present patent laws could be made which would be effective against foreigners and at the same time not be onerous and a hardship to domestic inventors. Your committee believes that in the long run and in the final outcome, our present system with regard to working and licensing is as efficient as that of any other country. In the dyestuff industry in particular there are so many non-patented commercial products and so many commercial products once patented now free from patent restraint that their production alone would form a basis for a very considerable industry, and your committee feels that the way to encourage that industry, if the

establishment of that industry in this country be a national necessity, is through a change in the tariff and the additional anti-dumping feature in the administration of the tariff and not through any change in the patent laws.

Once established, such an industry could develop and ultimately cope with any foreign combination upon fair and equal terms. Over 90 per cent of the tonnage and of the individual dyes used in the United States will be free from any patent restraint within the next four years; over 75 per cent of the dyes are now in that condition.

Availability of Raw Materials for Coal Tar Industry

The best information your committee has so far been able to gather is that this country can produce so-called coal-tar raw material in amounts sufficient for the needs of a complete domestic coal-tar chemical industry, inclusive of explosives and dyes, provided there is a certainty of outlet as to volume and continuity. Those engaged in manufacture here do not want to expand unless the dye users are willing to make corresponding contracts. In other words, it is a closed circle. If the dye users will contract sufficiently with the dye makers, the dye makers will contract with the coal-tar distillers and the industry will take a start. The initiative rests wholly with the users; if they cannot afford to contract the dye makers and the distillers cannot afford to make their contracts and additional investments.

Coal Tar Products

Benzol, *toluol* and the like are produced in sufficient amount in present installations of by-product coke ovens to provide all of these things that would be needed for a coal-tar chemical industry of a magnitude sufficient to supply the United States market; the separation of these materials from the gas that carries them is dependent upon the market and the demand therefor. There is no inherent defect in our coke industry with regard to the actual making of these things; the only question involved is whether it be more profitable to burn the benzol, toluol and the like contained in the gas as a fuel than to separate them from each other for purposes of sale. Ample supply can be provided before any plant that could use benzol and the like for dyestuff making could be erected in the United States and thereafter the supply of these materials can readily be kept up to any requirements.

The materials of the preceding paragraph are the ones used in the coal-tar explosives industry, as well as in the coal-tar medicinal and dyestuffs industries. Each of these three industries co-operates with the others to make full use of those materials, alone none can fully make use thereof nor succeed; the correct and proper utilization of these materials requires successful co-existence of all three industries in one and the same country.

Naphthalene and *anthracene* are contained in the tars produced in the United States in an amount sufficient for the needs of a domestic dyestuff industry, and it is merely a question whether it is more profitable to leave them in the creosote oil, where they now occur, or to separate them out of such oil and refine them for purposes of dye manufacture. Ample supply of either of them could be produced and provided at the same time or shortly after any plant could be erected in the United States for the use of these things in the production of dyes.

What has been said with regard to the supplies of naphthalene is also true of the supplies of *creosole*.

All the *creosote* oil contained in the total amount of coke-oven tar now made is separated from it and used. Increased production of creosote oil requires a greater

production of tar, and a greater production of tar is dependent upon increased installation of recovery coke ovens.

Phenol or *carbolic acid* supply is primarily dependent upon our deliberately selected method of coal treatment; to change that treatment so as to get more phenol would entail abandonment of other advantages which would not be compensated for by the increased amount of phenol so produced. Under present circumstances freights and haulages play an important part. At isolated plants, separated by considerable distances from each other, small amounts of phenol are produced, and the separation of the phenol at such individual places would be economically unprofitable, and in order to concentrate this amount of phenol to or at a point where separation could be conducted profitably would entail freight haulages much in excess of the value of the phenol that would thus be transported.

The only source of *phenol* in sight is that produced synthetically from benzol by means of sulfonation and subsequent melting with caustic soda; this depends in turn upon our benzol supply, and would be profitable only so long as the United States market is not killed by the dumping of foreign phenol thereon, whether such phenol be synthetic or distilled.

Salicylic production depends upon availability of phenol, and the production of benzoic acid depends upon the availability of toluol, which has heretofore been discussed.

Phthalic acid made from naphthalene by means of bichromate cannot successfully compete with the mercury and sulphuric acid process, which is protected by patents having about three years more to run.

Miscellaneous Chemicals and Raw Materials

Acetic anhydride can be made without trouble in this country, and will be made in this country as soon as the domestic demand is large enough and steady enough to warrant the installation of a suitable plant.

Nitric Acid.—All countries with the exception of possibly Norway and the countries importing from Norway are dependent upon Chile for the raw material for making nitric acid. It will not be profitable to make nitric acid from air in the United States until the value of the electric horse-power reaches a level of \$3 or \$4 a year, as it is in Norway.

Ammonia and its salts all depend upon recovery coke ovens, and such recovery plants are increasing as fast as circumstances will permit.

Barium chloride and other compounds of barium may be made from domestic barytes. A number of attempts have hitherto been made, but with indifferent success. Factories established within the last year promise to be successful.

Magnesium chloride of a sufficient purity to be used in the production of flooring is almost generally made from magnesite found in Greece, which is the only deposit known having sufficiently high purity; there are reports of suitable deposits in California and in Lower California, and with the completion of the Panama Canal the question of freights, which seems hitherto to have stood in the way of developing these deposits, may be eliminated. Other sources, less remote from centers of consumption, and using other materials, e.g., brine waste are about to be successfully operated.

Manganese in the form of pyrolusite is not known to occur in paying deposits in the United States; these are practically all in the Caucasus.

Potash.—In view of the great exertions that have been made for a number of years, both on the part of the Federal government through a number of its departments and a great many different groups of capitalists, there is nothing to be said in this report that

would be of any value with regard to increased production of potash either as fertilizer or as a chemical.

Yellow prussiate and *sodium cyanide* can be and have been made from domestic materials in such an amount as to provide practically the entire consumption or a great portion thereof in this country so long as there was a sufficient duty on them; the present duty is not enough to protect the American manufacturer, and those who were engaged therein have in large measure withdrawn from the business, but some are reported to be taking up manufacture cautiously and in limited amount.

Hydrosulphites in solution can be made from domestic materials without interference with any patent rights; the production of solid salts and derivatives are, however, still protected by patents that have a few years more to run.

Sodium nitrite is produced more cheaply as a by-product in Norway than it can be produced anywhere in the world; unless the price of the electric horsepower in this country sinks to a \$3 or \$4 level per year, as in Norway, this product cannot be manufactured in the United States.

Oxalic acid is and has been made to some extent in this country, and the information coming to your committee is that suitable efforts are being made to expand the capacity of existing plants.

Tartaric Acid and Citric Acid.—To make this country independent of others with respect to tartaric acid and citric acid would call for radical changes on the part of our grape growers and our lemon growers as to the policy of their business.

It is probably true that edible grapes do not produce argols (the crude material for tartaric acid) very largely, and that our domestic lemons do not produce as large yields of juice (the crude material for citric acid) nor as high an acidity as do the Italian lemons; therefore, an independent supply of the raw materials produced in the United States for tartaric and citric acids is, in the first instance, an agricultural problem, and, in the second instance, a market problem.

Finally, it should be pointed out that the United States is by no means the only country whose chemical and allied business has been strained or upset by the European war. Each and every other country has felt the strain. British committees have gone into the same subject of expanding British chemical industries, and not only that, but also into the question of making their very basic necessities, and the reports have so far been adverse to any immediate relief by domestic manufacture. The Boston Chamber of Commerce, through its committees, has arrived at the same conclusions for this country.

It is further clear that the stability of a complete domestic chemical industry, insofar as it depends upon foreign supplies, is bound up to a successful merchant marine and to an efficient foreign banking condition just as in all our foreign business.

Findings and Conclusions

Your committee finds as follows, as to the facts:

I. Prior to the hostilities the domestic chemical industry was utilizing and exploiting every reasonable opportunity to its full extent.

II. Since the outbreak of hostilities domestic industry has increased its output just as fast as physical means could be provided and physical obstacles overcome.

III. Since the outbreak of hostilities domestic plants that had theretofore been shut down or partly dismantled because of disastrous foreign competition are said to have resumed operation, with caution.

IV. That a 30 per cent duty on some coal-tar dyes for

over thirty years has not produced a real coal-tar dye industry in this country.

Your committee submits its conclusions as follows:

A. To prevent the unfair underselling alleged to be practiced by foreigners in this country, the adoption of an effective anti-dumping clause.

B. The so-called coal-tar "intermediates" which are the basis of the coal-tar chemical industry, inclusive of explosives, medicinals, and dyestuffs, should be assessed one-half of whatever the finished dyes are taxed for tariff purposes; all coal-tar dyes without exception to be taxed alike, namely, 30 per cent ad valorem and 7½ cents per pound specific.

C. Changes in the patent laws such as by compulsory licensing or compulsory working clauses are wholly ineffective, do more harm than good, and should not be attempted.

Your committee recommends that this report be submitted to the appropriate committees of Congress. Further, that this report be forwarded to interested organizations.

Respectfully submitted,

BERNARD C. HESSE, *Chairman.*

J. B. F. HERRESHOFF.

H. A. METZ.

I. F. STONE.

D. W. JAYNE.

J. MERRITT MATTHEWS.

ALLEN ROGERS.

Philadelphia Meeting of American Institute of Chemical Engineers

The seventh annual meeting of the American Institute of Chemical Engineers will be held in Philadelphia from Dec. 2 to 5, 1914. Hotel headquarters will be at the Hotel Adelphia.

Business meetings will be held at the Hotel Adelphia on Wednesday, Dec. 2, 10:30 a. m. and at the Franklin Institute on Friday, Dec. 4, 9 a. m. Sessions for the reading and discussion of papers are scheduled as follows:

Dec. 2, 11:15 a. m. (Hotel Adelphia):

D. D. Jackson, The manufacture and application of the artificial zeolites (permutite) in water softening.

Allerton S. Cushman and George W. Coggeshall, Feldspar as a possible source of American potash.

Dec. 2, 8:15 p. m. (Franklin Institute):

George O. Smith, Distribution of Industrial Opportunities.

Dec. 4, 10 a. m. (Franklin Institute):

John V. N. Dorr, Hydrometallurgical apparatus and its use in chemical engineering.

E. H. French and James R. Withrow, Hardwood distillation.

Jokichi Takamine, The chemical industries of Japan. Bernhard C. Hesse, Need of up-to-date manufacturing statistics.

Dec. 4, 8:15 p. m. (University of Pennsylvania):

S. P. Sadtler and S. S. Sadtler, Ore flotation.

Edw. Gudeman, Aspects of some chemical industries in the United States.

Excursions will be made on Wednesday afternoon to the Atlantic Refining Company and United Gas Improvement Company, on Thursday (all day) to the Welsbach Company works in Gloucester, N. J., the New York Shipbuilding Company, and the Farr & Bailey Linoleum Works in Camden, N. J., on Friday afternoon to the Commercial Museums and the Laboratories of the University of Pennsylvania, and on Saturday to the Barrett Manufacturing Company in Frankford, Philadelphia. A subscription dinner will be held on the evening of Thursday at the Hotel Adelphia.

Chloridizing Ores at Silver City, Utah.

(Editorial Correspondence)

Interest in the revival of chloridizing processes in Utah has centered mainly in the work of N. C. Christensen, Jr., at Silver City, and Theodore P. Holt and George H. Dern, at Park City. Former issues of METALLURGICAL AND CHEMICAL ENGINEERING¹ have made frequent reference to these developments, and one issue² described the Park City process in detail. The principles underlying the work of Mr. Christensen at Silver City are similar to those applied at Park City, but the method of application is quite different as will appear from the following notes.

The Knight-Christensen Metallurgical Co.

The mill at Silver City, Utah, shown in Fig. 1, was erected primarily for the local treatment of ore from

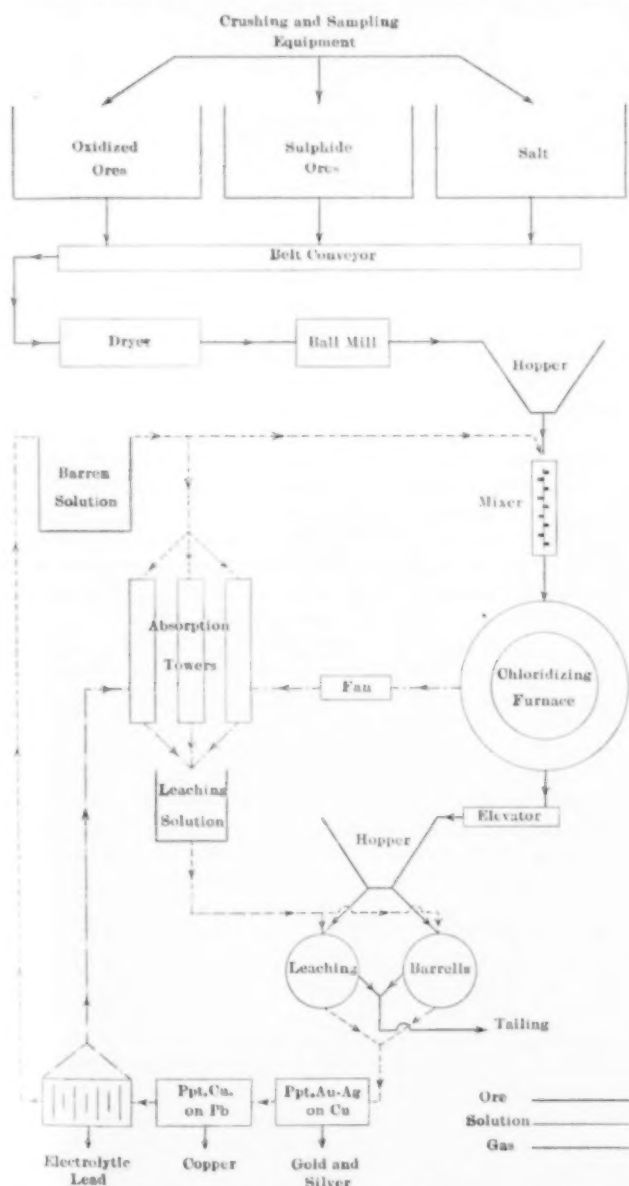


FIG. 1.—ORE-TREATMENT DIAGRAM, KNIGHT-CHRISTENSEN MILL

the mines of Mr. Jesse Knight, who has been deeply interested in the development of a metallurgical process and has given commendable financial support to the

ideas of Mr. Christensen. The ores from the Knight mines afforded an excellent variety of oxidized, sulphide and silicious material from which to make a mixture most suitable to the process of treatment. Silver is the metal of principal value; copper, gold and lead also occur, and are of importance in about the order named. In metal contents the different ores range from 4 to 30 oz. silver and 0.03 to 0.20 oz. gold per ton, 1 to 8 per cent lead, and from a trace of 1.75 per cent copper.

The sulphides provide the fuel necessary in the chloridizing roast, and in this respect the metallurgical conditions differ from those in the plant at Park City where coal is added to the ore-mixture before roasting. Otherwise the process is similar except in method of application. Briefly, it consists in roasting a mixture of ores and salt; condensing the acid roaster gases in salt solution; leaching the roasted ore with this solution, and precipitating the metals successively—gold and silver on copper, copper on lead, and electrolyzing the final lead solution. The diagram in Fig. 1 presents the main features of the process.

Preparation of the Ore-Mixture

The crushing and sampling department comprises the usual machinery for such purposes and affords accurate samples of ore received from the different mines. Ores and salt are both crushed to $\frac{3}{8}$ -in. before delivery to their respective storage bins. Adjustable mechanical feeders deliver fixed quantities of the different ores and salt onto a belt conveyor that feeds the dryer. An effort is made to maintain about 4 per cent of pyrite in the mixture, and salt is added to the extent of 8 to 10 per cent. Salt costs \$4.15 per ton at the mill.

From the dryer the mixture is passed to the ball mill, shown in Fig. 2, where it is ground to the requisite de-



FIG. 2.—KNIGHT-CHRISTENSEN MILL, SILVER CITY, UTAH

gree of fineness. This ranges from 8 to 20-mesh and depends on the character of the ore under treatment. It is recognized that inasmuch as sulphides are used for fuel, the finer they are ground the more uniform their distribution through the mixture, with consequent reduction in quantity required and improvement of the chloridizing roast. Compact, silicious ores require finer grinding than do the more porous oxidized iron ores. Salt, of course, becomes thoroughly disseminated through the mass in the process of grinding.

The next step is the addition of 8 to 10 per cent of barren mill solution to the ore-mixture. It is essential that this moisture be uniformly distributed throughout the mass in order that the physical condition of the ore-

¹This journal, Nov., 1913, pp. 605 and 657; April, 1914, p. 222; Oct., 1914, p. 658.

²Chlorination at Park City, Utah, this journal, July and August, 1914, pp. 431 and 492, respectively.

bed on the furnace hearth shall be the same at all points. A simple and effective mixing device has been constructed, consisting of a vertical pipe 4 ft. long and 6 in. in diameter, within which is mounted a central revolvable shaft provided with horizontally projecting teeth arranged at intervals along its length. The shaft rests in a step-bearing and makes 480 r.p.m. Ore and solution are fed at the top of the pipe, and a uniformly moist, porous mixture is delivered at the bottom. Several mixing devices had been tried prior to the adoption of this one, but none gave satisfaction.

Chloridizing-Roasting

The roasting furnace consists essentially of a horizontal, annular, revolving, perforated hearth, 22 ft. outside and 10 ft. inside diameter. A feed hopper is erected at one point over the hearth, and adjacent to it on either side is the ignition box and the discharging device. The hearth is constantly under downward suction from a fan placed at one side of the furnace. A roaster of this size operating under the conditions existing at Silver City has a capacity of 300 tons in 24 hours.

In operation, the hearth makes one revolution in 40 minutes. The ore is fed onto the hearth continuously in a loose, porous layer from 4 to 8 in. deep, according to the fineness of the mixture. Finely crushed ores are deposited in shallow beds. The grates have per-

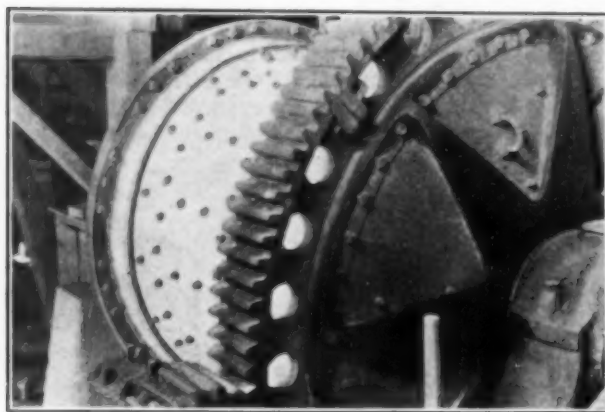


FIG. 3.—BALL MILL, KNIGHT-CHRISTENSEN MILL

forations $\frac{1}{8}$ in. by 1 in. Ignition of the charge is started as it passes under the oil-fired furnace and is continued by the down draft throughout the revolution of the hearth to the point of discharge. Careful adjustment of the temperature is required to get uniform ignition and prevent sintering the ore, and the fire-box is kept at a dull red heat with an oxidizing atmosphere. The temperature of the roast is about 700 deg. C. It can run as low as 500 deg., but may not exceed 800 deg. without danger of loss by volatilization. Oil consumption varies with the depth of the bed and fineness of the ore, and ranges from $\frac{1}{2}$ to 1 gallon per ton. The cost of oil, crude distillate, is about ten cents per gallon in tank-car lots.

The roast is loosened and detached from the hearth by a plow that extends nearly to the hearth surface. A screw conveyor engages the loose mass and removes it. A view of this mechanism is given in Fig. 3, which shows also a part of the annular hearth and the feed hopper. In order to provide a layer of coarse material on the hearth beneath the raw charge, to protect the grate from corrosion and prevent fine ore running through the perforations, a portion of the roasted ore is allowed to pass over the plow and fall onto the hearth

just before passing under the feed hopper. The chloridized ore is still hot when removed from the roaster. It is elevated to a storage hopper where chloridization continues until such time as the ore is withdrawn and charged into the leaching barrels.

As the ore-bed is constantly under diminished pressure, no chlorine or other fumes contaminate the mill atmosphere. A steel fan driven by a 15-hp motor draws the fumes from beneath the hearth and forces them into wooden towers containing horizontal wooden partitions through which barren mill solution is descending. Emerging from the towers the solution contains SO_2 , Cl, and about 2½ per cent HCl, and is almost at boiling temperature. This is the active leaching solution with which the chloridized ore is treated. Of course, the solution gradually becomes saturated with salt as it circulates through the leaching barrels.

Metals Go Into Solution Rapidly

Ore and solution are both hot when they are brought together in the leaching barrels, and conditions are most favorable for rapid solution of the chloridized metals. The barrels are spherical in shape, mounted on trunnions, and contain filter-bottoms. A charge consists of five tons of ore, and solution in the ratio of 2½ to 1 of ore. When a barrel is full it is allowed to stand for about 10 or 15 minutes before percolation commences. The pregnant solution flows to the precipitating department. After about 2½ hours of percolation the charge receives a water-wash for $\frac{1}{2}$ hour, after which the tailing is discharged by rotating the barrel.

The amount of wash water used is only sufficient to counterbalance the loss of that quantity of mill solution used to moisten the ore, plus that evaporated from the towers and tanks. As the metals go into solution very rapidly they are removed from the gangue early in the period of percolation. The solution applied toward the end of the period is practically a barren wash, and the final wash with water serves mainly to recover salt. Enough water remains with the tailing to make it flow like thick molasses when discharged from the barrels. No fouling of solution takes place, as it is renewed practically every day. Iron does not go into solution to any great extent, and even when treating oxidized ores high in iron the pregnant solution will contain but 0.1 per cent of that metal.

If much gold is present in the ore it is considered necessary to have the mill solution stronger in chlorine, and that element must be added in some form or other. Manganese dioxide existing naturally in the ore, or added as a constituent of the roaster feed, would generate chlorine by reaction with the chlorides present.

Precipitation on Metals and by Electrolysis

The gold, silver and copper in the pregnant solution are precipitated successively on more electro-positive metals—silver and gold on copper, and copper on lead. The final lead solution is electrolyzed under high current density. Precipitation is accomplished in revolving wooden drums, or wood-lined trommels, containing the necessary metals in the form of small spheres. The metal precipitated in one drum is removed by settlement or filtration before the solution flows to the next drum. This method of precipitation is continuous, rapid and highly efficient, as the solution is warm and the surface of the precipitating metal is constantly kept clean by abrasion. The electrolysis of the lead solution yields a spongy product which is made compact by rolling before it is melted. The acid gases from electrolysis are conducted to the towers where, together with the roaster gases, they are absorbed in the barren mill solution that comes from the precipitation department.

The metallic products are high grade, and after melting are ready for market. Some of the copper and lead can be converted into suitable forms for precipitating purposes, and the accumulating balance can be disposed of in the market.

Wooden pipes and rubber hose are used for the transportation of the mill solution. There are no valves and

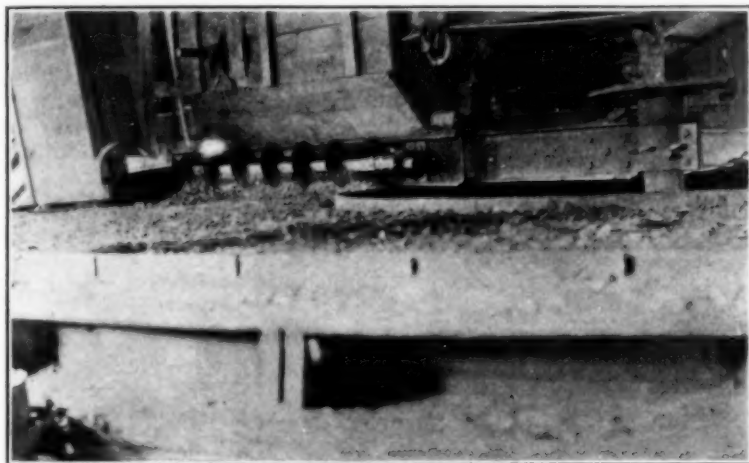


FIG. 4—CHLORIDIZING FURNACE, KNIGHT-CHRISTENSEN MILL

no pumps in the system. All elevating of solution is done by means of wooden montejus. Porcelain pumps could be used successfully under a low head, and probably would be adopted in a new plant. Some porcelain pipe also could be used to advantage, as wooden pipe does not swell under the action of salt solution as with water, and is likely to permit some leakage.

While this mill of the Knight-Christensen Metallurgical Co. is regarded as an experimental plant on a large scale, nevertheless its sponsors are satisfied that they have demonstrated a process that will be profitable. Another mill employing the same methods and apparatus is expected to be in operation in the Park City district in the near future, and we hope later to present some data thereon.

The Effects of Pickling Upon the Corrosion of Iron

BY E. A. RICHARDSON

In connection with a test that was to be made upon the corrosion of sheet iron, the question arose as to how the surfaces should be cleaned. Since a number of methods could be used, it was necessary to know what effect these different methods would have on the subsequent corrosion. A small preliminary test of short duration was, therefore, made to determine the best method for cleaning the specimens to be used in the larger test.

In much of the literature that deals with the corrosion of iron and steel, little mention is made of the method of preparing the samples for test, that is, little attention seems to have been given to the means of eliminating the effects of scale on the specimens of sheet metal and in particular to the effect produced when this scale is removed by pickling.

It is the object of this article to show that for short time tests the effect of pickling exerts a great influence upon the rate of corrosion, and that tests in which this effect is not eliminated are not comparable and may even be unreliable and misleading.

This conclusion is based upon the results of a test made upon four kinds of commercial sheet irons. The samples tested were 16 gauge in thickness and 4 in.

square. In order that they might be comparable before pickling, they were annealed in a muffle furnace at the same time at a temperature of 750 deg. C. and cooled slowly.

The samples were pickled as follows:

- (1) Scale removed by grinding on an emery wheel,
- (2) Scale removed by pickling in sulphuric acid,
- (3) Scale removed by pickling in sulphuric acid, and the samples washed in water and dipped in dilute nitric acid.
- (4) Scale removed with sulphuric acid and the samples washed with water and dipped in a mixture of ammonia water and hydrogen peroxide.

After pickling, the test pieces were washed thoroughly with water and dried by dipping in alcohol. They were then measured and weighed and exposed to the weather in a wooden rack from October 1 to January 1.

The four materials used analyzed as follows:

Sample	Sulphur	Phosphorus	Carbon	Manganese	Copper
a	0.020	0.003	0.01	0.052	0.048
b	0.059	0.117	0.10	0.319	0.268
c	0.045	0.094	0.10	0.406	Trace
d	0.051	0.009	0.035	0.044	0.044

It was noticed at once that the method of pickling had a decided influence upon the starting of corrosion. The samples which had been dipped in nitric acid were the last to start rusting; in fact they were rained upon several times before any signs of rusting appeared. The others started to rust after the first rain.

The duration of this test was ninety-five days, after which the samples were examined before removing from the rack, the examination being made by three independent observers. All three agreed to the same classification, which was as follows:

First. Sample "b." This material was by far the best. The rust was red in color and adherent and was smooth and fine grained.

Second and Third. Samples "a" and "d." These materials were corroded about equally. The rust was coarse-grained and was becoming loose.

Fourth. Sample "c." This material was much the worst. The rust was yellow in color, was coarse-grained and very loose.

After cleaning the surface of the samples with neutral ammonium citrate solution, the same three observers again observed them. The results were as before.

After these inspections the samples were reweighed and the loss in weight computed in grains per square centimeter. The results are as follows, each figure being an average of two:

METHOD OF CLEANING SURFACE

Sample	Grinding	Sulphuric acid	Sulphuric and nitric acids	Sulphuric acid and ammonia and peroxide
b	0.0372	0.0420	0.0293	0.0389
a	0.0597	0.0600	0.0441	0.0512
d	0.0651	0.0463	0.0497	0.0476
c	0.0952	0.0967	0.0646	0.0864

From an examination of the above figures it is evident that the method of cleaning the surface of test pieces before exposure has a decided influence upon the rate of corrosion. This is particularly noticeable when a passivating agent such as nitric acid is used. Upon long exposure tests this effect would undoubtedly be decreased and might perhaps be eliminated.

The author acknowledges several suggestions made by Mr. L. T. Richardson during the progress of this test.

Warren, Ohio.

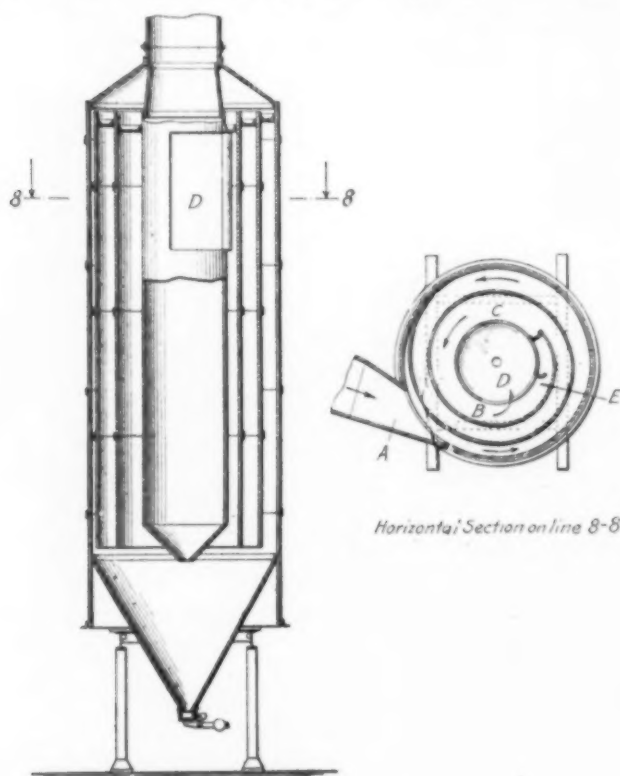
The Gas from Blast Furnaces, Its Cleaning and Utilization

BY J. E. JOHNSON, JR.

(Concluded from p. 692.)

PRIMARY WET CLEANING

For primary cleaning, in Europe in particular, a separation of the dust by the use of water has been preferred for many years to a dry separation, on account of the very much greater efficiency obtained in cleaning, and on account of the importance of reducing the water vapor contents of the gas to a minimum, thus allowing more efficient combustion. The cooling and washing of the gas are usually performed simultaneously, sufficient water being used to reduce the temperature of the outgoing gases to practically the tem-



FIGS. 11 AND 12—DYBLIE WHIRLER

perature of the incoming wash water. Experience has shown that cooling the gas in this manner, to allow condensation and separation of the water vapor, causes less attendant loss of heating efficiency than prevails in heating with vapor-laden gas.

ZSCHOCKE SYSTEM

Zschocke washers have been used almost entirely in Germany for wet primary cleaning. These consist of cylindrical or square steel towers fitted with a series of wooden grids or hurdles placed at suitable intervals within the apparatus. These hurdles are arranged in such a manner that the water, which is sprayed in at the top of the tower, is broken up into very fine streams, which drip down between the grids and meet the gas coming up, the gas being introduced at the bottom of the tower. The intimate contact so obtained wets down the dust, which is carried with the water to the bottom. These Zschocke towers are usually water-sealed and cone-shaped at the bottom, and the latest type has a siphon arrangement; in either case, the dust is readily removed from the bottom of the apparatus.

Zschocke towers have been found sufficient to cool and clean the gas to the proper degree for use in hot-blast stoves, under boilers, and for similar purposes. A fan washer, into which water is introduced, is frequently used as an auxiliary to the Zschocke towers for primary cleaning, especially when the scrubbing capacity of the towers is small.

A water separator, equipped with internal baffles, is usually located beyond the washer to allow separation of the entrained water.

Zschocke washers are used considerably in the United States, and some additional systems have also been developed here for the wet separation of dust; for instance, the Duquesne spray tower and the Steinbart

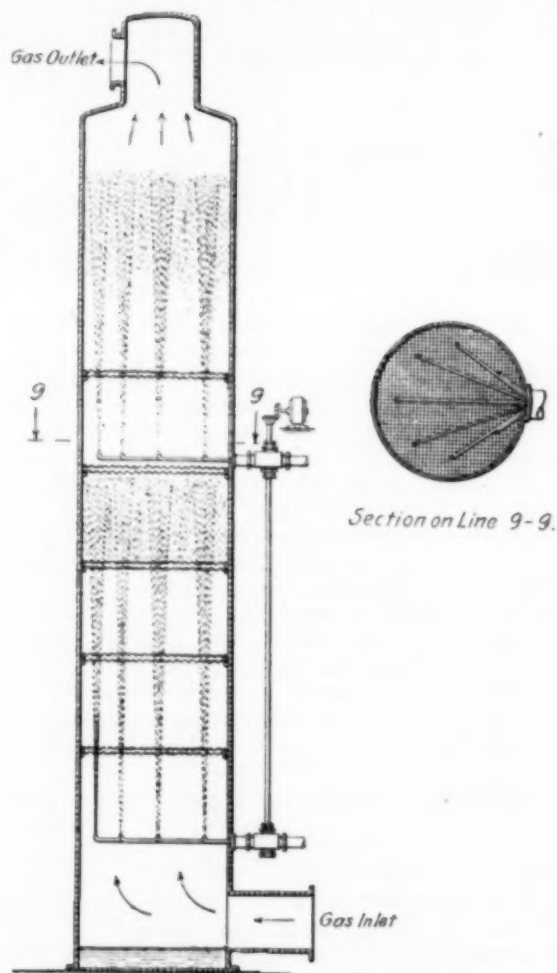


FIG. 13—DUQUESNE SPRAY TOWER

spray tower. The basic principle of these spray towers consists of the creation of a rain or spray by means of suitably arranged nozzles, and the gas is cleaned and cooled in passing through this spray.

DUQUESNE SPRAY TOWER

The Duquesne tower consists of a shell about 80 ft. high by 12 ft. in diameter. As shown in Fig. 13, the tower contains five sets of double screens, the sets being spaced 6 ft. 10 in. apart. Under the first set of screens are distributed seven nozzles, the feed water for which is controlled by a valve outside the tower. Under the fifth set of screens, seven similar nozzles, also controlled by a valve outside the tower, are distributed, just above the range of the lower nozzles.

The controlling valves have a revolving core which successively blocks off the openings to the different nozzles, thereby temporarily stopping the flow of water

and creating an area of low pressure directly above the nozzle. When the core has passed, the flow of water resumes through this nozzle and sprays the gas which has reached this point. The core is revolved electrically, at the rate of about 15 revolutions per minute, and a 5-hp motor is ample to operate four valves, which are sufficient for two towers.

The screens, which are placed above the nozzles, break up the water into fine drops, permitting intimate contact of the gas and the water.

In the operation of these towers at Duquesne, the gas rises through the scrubber at the rate of 4 ft. per second, and the water at the rate of 60 ft. per second with a head of 35 lb. main pressure. The gas is cooled

the cylinder rests, and as the shaft revolves, the part of the screens which has been immersed rises from the water with the meshes covered with thin films of water, thus allowing thorough contact with the gas as it passes through the perforations.

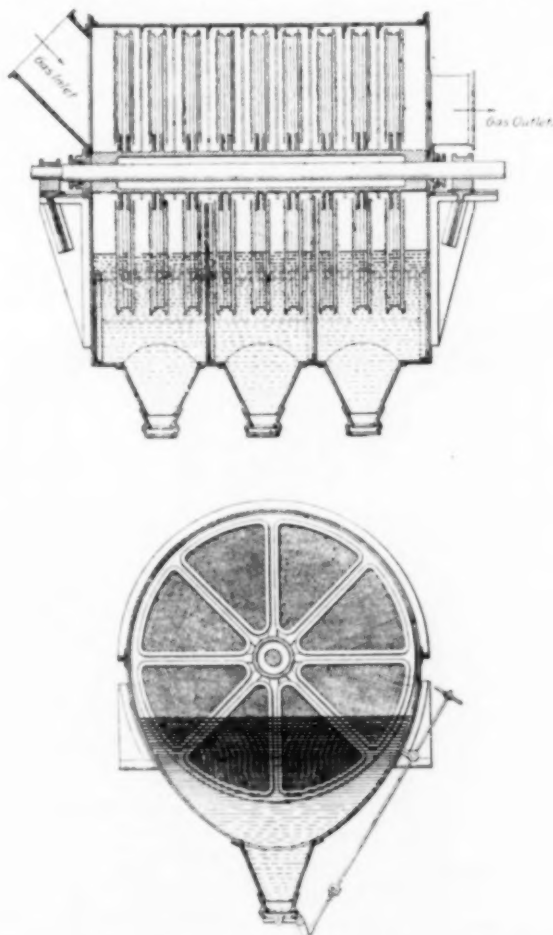
FINAL WET CLEANING

(Some of these systems can also be applied to primary cleaning.)

The amount of cleaning accomplished in Zschocke and similar towers, and in the Bian washer, while satisfactory for stoves and boilers, was found to be not sufficient when the gas was destined for use in gas engines, and the systems of Theisen and Schiele were developed for this purpose.

THEISEN GAS WASHER

The Theisen washer, as shown in Figs. 16 and 17, consists of a casing lined with a special wire netting, within which revolves at a high speed, a drum carrying numerous fan blades set at oblique angles to the axis of rotation, these blades or vanes being so fitted that they form a continuous spiral curve. This allows the gas to be drawn in at one end of the casing and expelled at the other end. Water is admitted at the side of the casing and is converted into a fine spray by the revo-

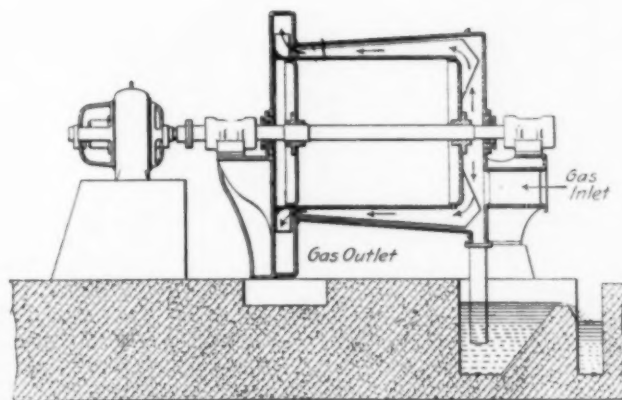
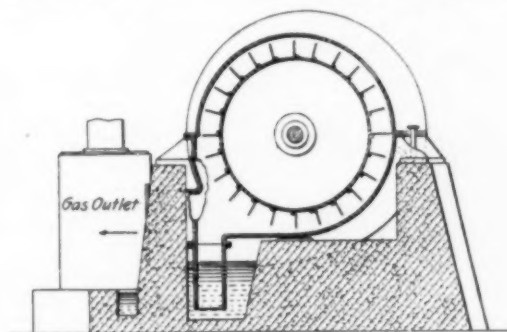


FIGS. 14 AND 15—BIAN GAS WASHER

down very effectively, the temperature of the outgoing gas being only from 5 deg. to 6 deg. Fahr. above the temperature of the incoming water, while the moisture content averages only about 0.5 grain per cubic foot above the saturation point at the temperature of the outgoing gas.

BIAN GAS WASHER

The Bian gas washer, as shown in Figs. 14 and 15, consists of a stationary horizontal steel cylinder through which the gas passes from one end to the other. Inside the cylinder, there slowly revolves a shaft which carries a number of vertical disks consisting of wire netting of fine mesh. The diameter of these disks is very slightly less than the inside diameter of the cylinder, and this arrangement necessitates the gas passing through the openings in the screens as it travels through the apparatus. The screens, to the extent of nearly half their diameter, dip into water contained in a trough upon which the open bottom of



FIGS. 16 AND 17—THEISEN GAS WASHER

lutions of the blades, and the spiral arrangement of these blades causes the spray to flow in the opposite direction to the gas, which passes through this spray, being simultaneously cleaned and cooled. The dirty water leaves the apparatus by a water seal at the bottom.

The Theisen and Schiele systems of final wet cleaning have for years given very satisfactory results, but are now being gradually superseded by systems requiring less capital expenditure and less operating expense. Most of these systems can be used for primary cleaning as well as for final cleaning, by installing in two stages. The most important of the wet cleaning systems which perform as efficient cleaning with the consumption of

much less power and water than the Theisen and Schiele systems are the disintegrator system of Theisen, the disintegrator system of Schwarz-Bayer, the Fowler & Medley rotary washer, and the Feld rotary washer, while the Halberger-Beth dry cleaning system of filtration through canvas is remarkably efficient in cleaning and is cheap to operate. Following is a detailed description of each of the systems mentioned, together with several other modern systems:

THEISEN DISINTEGRATOR GAS WASHER

There are two styles of Theisen disintegrator gas washers. One style consists of a casing in which the gas enters by two apertures at the base of the apparatus and is washed by a spray of water in a perforated drum or cage equipped with vanes, the drum revolving within a stationary drum, the gas being drawn through the apparatus by a fan mounted on the same shaft and discharged with the necessary pres-

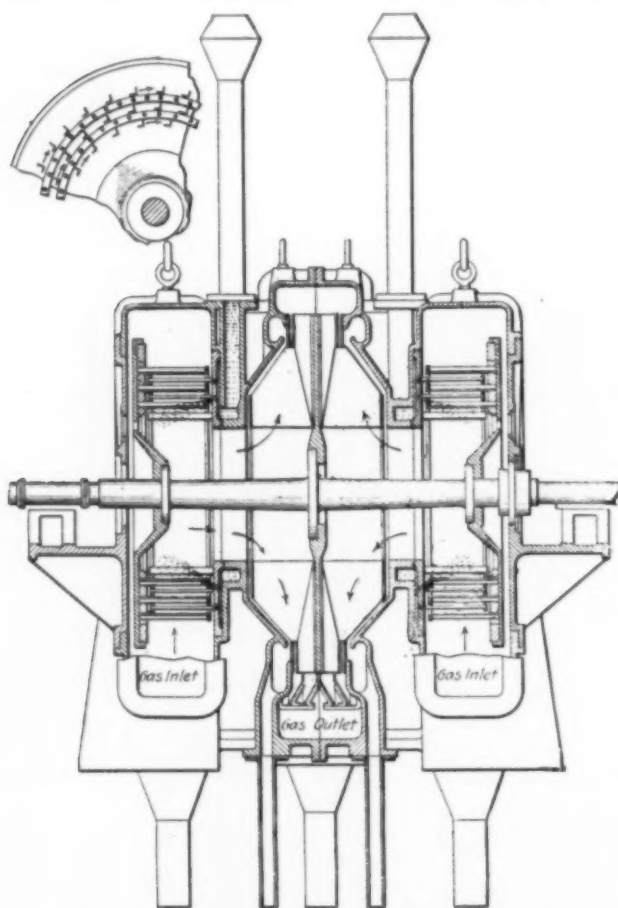


FIG. 18—THEISEN DISINTEGRATOR GAS WASHER

sure to carry it to the point of consumption. The second style also has the fan mounted on the shaft, but the fan is inclosed within the disintegrator.

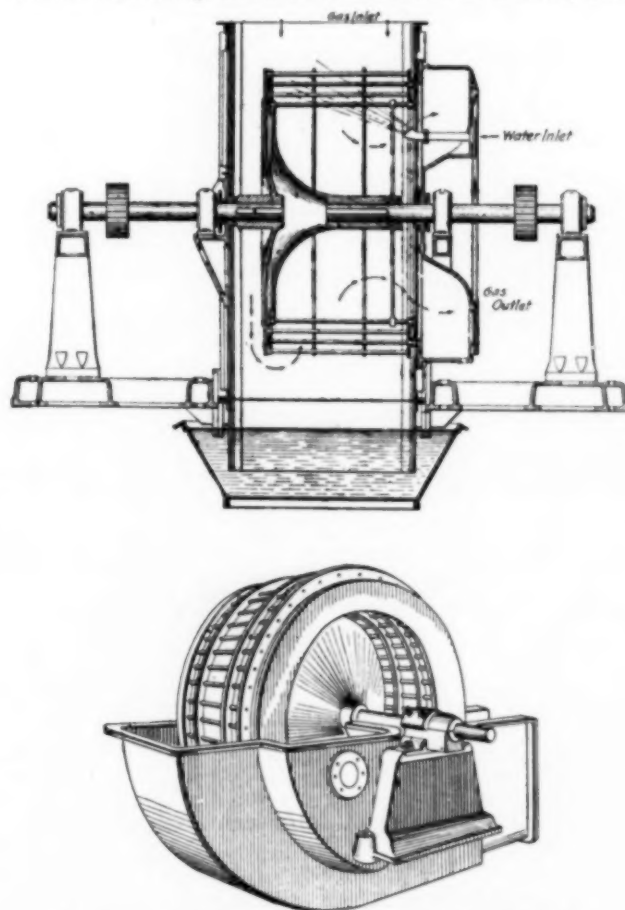
The Theisen disintegrator consists of a series of rotary and stationary perforated drums or cages arranged concentrically within one another, as shown in Fig. 18. The stationary drums consist of round bars and the revolving ones of angle bars. The hot raw gas enters the apparatus at the bottom, meets the effluent water and undergoes a preliminary cooling and cleaning in the lower part of the machine. The gas is drawn in counter-current through the series of rotary and stationary drums by means of a fan. The water is converted into a fine spray by the centrifugal action of the rotating drums, and the gas, passing through this spray, is cleaned. The fan is located in the same

casing and on the same shaft as the rotary disintegrating drums, the shaft being direct motor driven. Fresh water is introduced into the innermost rotating drums in the form of a finely divided spray.

The cooling and cleaning of the gas and production of the pressure necessary to conduct the clean gas to its point of consumption are all performed in one apparatus and with one motor. It is stated that this disintegrator is an improvement over the former. Theisen apparatus, requiring much less power and water, and performing the necessary cleaning of the gas without preliminary towers.

SCHWARZ-BAYER DISINTEGRATOR GAS WASHER

The Schwarz-Bayer system of gas cleaning makes use of the disintegrator principle, and its general arrangement is simple. The complete set of gas-cleaning apparatus consists of a disintegrator in connection with a saturating chamber in the form of a hood; then



FIGS. 19 AND 20—SCHWARZ-BAYER DISINTEGRATOR GAS WASHER

a fan placed immediately behind the disintegrator, and finally a water separator. In case both primary and final cleaning are desired, two such sets of apparatus are used, the second of which further cleans the gas which has been primarily cleaned in the first.

The disintegrator, as shown in Figs. 19 and 20, consists substantially of two sets of steel pins, cold-riveted to two steel disks, which disks are set side by side and revolve in opposite directions. The pins of one revolving disk, which interlace with the pins of the other revolving disk, form with the water, through the effect of rotation and dripping, a fine spray or mist, which allows a thorough mixture of the water with the gas traveling among and between the pins before leaving the apparatus.

The gases from the blast furnace pass from the raw gas mains directly into the disintegrators without previously passing through Zschocke towers or similar preliminary washer or cooler. The gas enters through the top of the hood and passes toward the center of the disintegrator, while water is being introduced through the sides to the center. The hood acts to some extent as a pre-cleaner and cooler, as some of the spray from the disintegrators is thrown into the hood and there comes in contact with the hot gas and rapidly evaporates, simultaneously cooling the gas. By the revolution of the disintegrator the water is projected toward the periphery of the apparatus and is broken up into a fine spray; the gas mixes thoroughly with this water and is cooled, and most of the dust contained in the gas is precipitated. The gases pass through the disintegrator in a current counter to that of the water.

The application of the counter-current principle enables the gas to encounter cleaner and colder water in its passage through the disintegrator; hence it is better cleaned, and its temperature is reduced more nearly

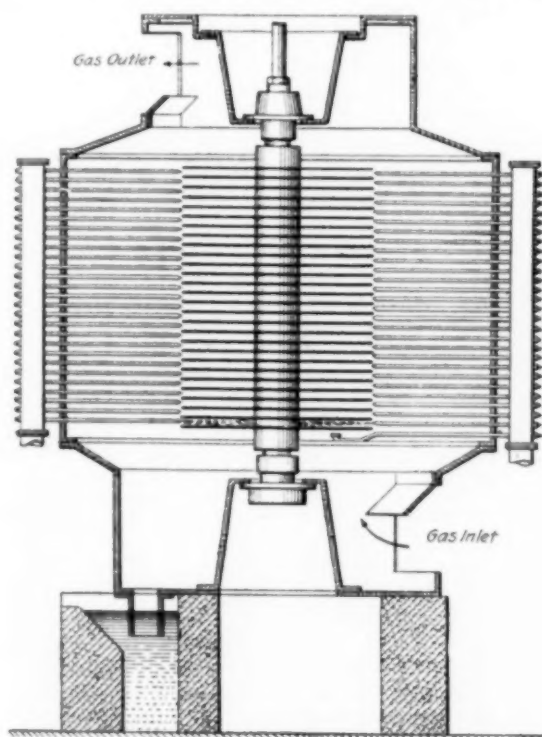


FIG. 21—FOWLER & MEDLEY VERTICAL GAS WASHER

to the temperature of the entering cooling water. This principle has the effect of materially reducing the amount of water and power consumed. Each disk is direct driven by an individual motor and the speed is determined by the degree of cleanliness desired in the gas. The gas is drawn through the disintegrator by means of a fan located immediately behind the disintegrator apparatus, and passes from the fan to a water separator.

The use of pins in this apparatus as a disintegrating medium allows the passage of the gas with very little resistance, and a consequent saving in power. There is also very little possibility of the dust settling on the pins and clogging up the apparatus.

FOWLER & MEDLEY VERTICAL GAS WASHER

This apparatus, as shown in Fig. 21, consists of a circular cast-iron casing containing a revolving shaft running vertically through the middle. On this shaft are fixed a number of disks, made either of steel or of

cast iron, depending upon whether the water used is alkaline or acid. Each disk is equipped with a collar separating it from the adjoining disks, and each collar is punched or drilled with six holes, through which six bolts pass vertically, thus holding all the disks in place. The shaft is direct driven with a vertical-spindle motor. Two fixed water sprays are provided for each disk, diametrically opposite each other, one on each side of the washer and projecting between each pair of disks. The jets of water, which are introduced through nozzles having about $\frac{1}{8}$ -in. openings, enter with sufficient pressure to strike the collar between the disks, and, as the disks revolve, the water is thrown against the top and bottom of these disks and then against the outside wall of the casing, creating a fine spray or mist in the space between the outer edge of the disk and the wall of the casing, through which space the gas passes.

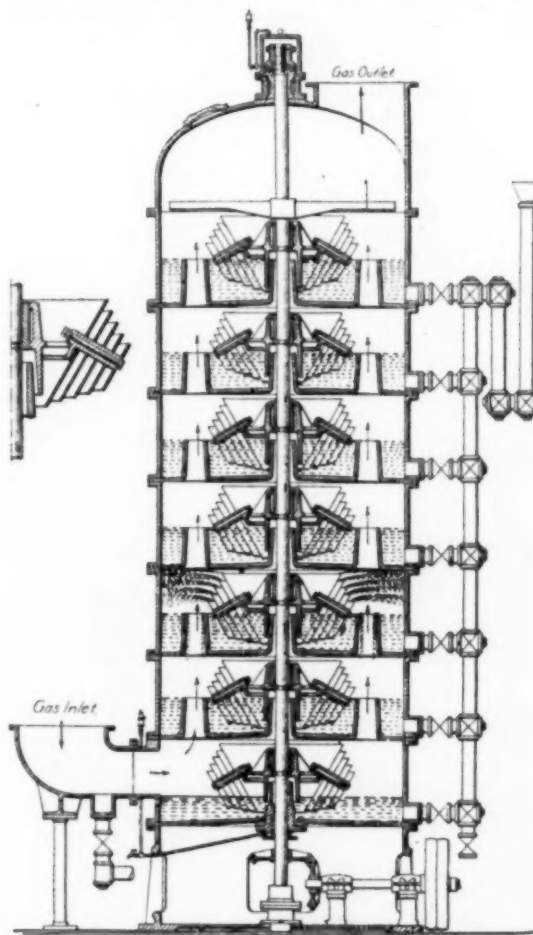


FIG. 22—FELD GAS WASHER

The gas enters the washer at the bottom, passes through this spray or mist, and leaves clean at the top.

This washer can be used for either primary cleaning or final cleaning, or both; in case final cleaning is desired, two washers would be used in series, the first apparatus to clean the gas sufficiently for primary purposes and the second apparatus to finish the cleaning of the gas for gas-engine use.

FELD GAS WASHER

The Feld washer, as shown in Fig. 22, consists of a series of superimposed sections, the bottom of each section being provided with ports for the passage of gas. The gas enters the bottom of the washer and passes from chamber to chamber to the top, whence it is led away. Each section or chamber is provided

with a series of cones perforated at the top and mounted upon a cast-iron spider, which is carried on a vertical shaft. The shaft is suspended at the top in a specially designed anti-friction bearing, arranged so as to reduce the power required for operation to a minimum. The water is admitted into the top of the washer and overflows from section to section through the gas ports, the dirty water saturated with dust leaving the bottom of the washer.

When the shaft revolves, the cones do likewise, and the water is raised by centrifugal force along the inner sides of the cones and is atomized at the upper edge. This upper edge of each cone is a little higher than the next outer one, thereby forming a certain number of horizontal sprays of water, depending on the number of cones. The upper portion of the outer cone, which is somewhat higher than the inner one, is perforated. The inner cones supply water to the perforated surface of the outer one. This results in the

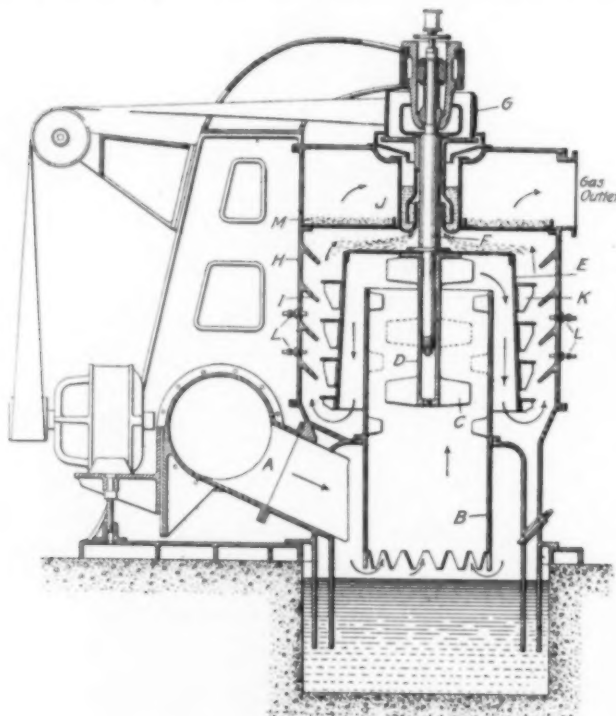


FIG. 23—RECO CENTRIFUGAL GAS WASHER

formation of a series of cascades composed of very small drops of water, through which the gas must pass en route through the apparatus.

The washing is accomplished mostly in the lower sections, while the upper sections perform primarily the function of cooling the gas.

For primary washing, the Feld washer is constructed with seven chambers or sections, the lower three being the washing chambers, the fourth one being a separating chamber and the upper three being the cooling chambers. For final washing, in the case of the gas being required for gas-engine purposes, the gas after being primarily cleaned is passed through an additional washer of the same general arrangement.

RECO CENTRIFUGAL GAS WASHER

This gas washer is constructed by the Roessing-Ernest Company, of Pittsburgh, Pa., and is designed to cool, clean and, if necessary, dry the gas in one apparatus. This washer consists substantially of a vertical outer casing, a tube whose lower end is provided with serrations extending to within a few inches of a water seal, a revolving inverted cup, and a sleeve casing attached to the inverted cup. The outer casing, the cup,

the tube, and the sleeve casing are provided with shelves and vanes. The apparatus is belt-driven. The spindle of the rotor on which the driving pulley is fastened is hollow, and the weight of the rotor is taken up by the shaft inside of this sleeve held by a ball bearing which is backed by a rubber buffer in order to equalize any irregularity during rotation.

As shown in Fig. 23, the hot gas enters the apparatus at the point A, passes over the water, a certain amount of which the gas takes up by evaporation, and then passes into the tube B through the serrations at its base. During its passage through this tube the gas and water vapor are subjected to a thorough beating and mixing by the action of the vanes C of the revolving sleeve casing D, fastened to the top of the inverted cup E. The gas passes into this inverted cup, which is rotated by the driving sleeve F and the pulley G, and then flows downward, around and under the lower edge of the cup and then upward between the cup and the outer casing H. The outer surface of the revolving cup is provided with concentric shelves K and the outer casing H is provided with downwardly inclined shelves I, which receive the washing water from the water-sealed stuffing box J and through a series of water pipes L. The water, falling on the rapidly rotating shelves of the cup, is thrown by centrifugal force against the inner walls of the casing and thence flows downwardly along the inclined shelves, dripping on to the next rotating shelf, and so on. In this way the gas, while subjected to a thorough whirling and beating action, has to pass upward through several films of finely divided water or spray while the water passes downward, carrying with it the separated impurities.

The apparatus operates on the counter-current principle, the cleanest gas passing from the apparatus meeting the cleanest water entering the apparatus.

The upper part of the casing is provided with a rack which, it is stated, can be packed with suitable drying material in case it is desired to dry the gas before leaving the apparatus.

SEPULCHRE GAS WASHER

This system is designed as a final washer to further clean primarily cleaned and cooled gas to the degree necessary for use in gas engines. The principle of this system consists in creating in a vertical tower a very fine spray or mist of water by means of an injector of the Korting type, in which water under pressure is atomized by means of compressed blast-furnace gas, the spray being produced by the expansion of the compressed gas. An intimate mixture of the spray so formed, with the dirty gas entering the apparatus, is obtained by the arrangement of the apparatus.

A separator is provided in connection with this apparatus, which consists substantially of a cone arranged in the lower part of the tower in such a way as to leave between the base of the cone and the walls of the tower a very narrow passage, through which the gases are forced over the surface of a water seal, where the dust and water vapor are deposited.

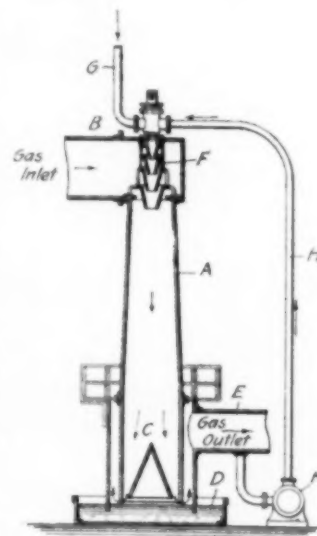


FIG. 24—SEPULCHRE GAS WASHER

In the accompanying drawing, Fig. 24, A is the vertical tower, the lower end of which terminates a short distance above the surface of the water seal D. Within the lower end of the tower is arranged a conical deflector, C, and near the top of the tower is the gas inlet, B. The lower section of the tower A is surrounded by a casing which is open at the bottom and extends beneath the surface of the water in the seal.

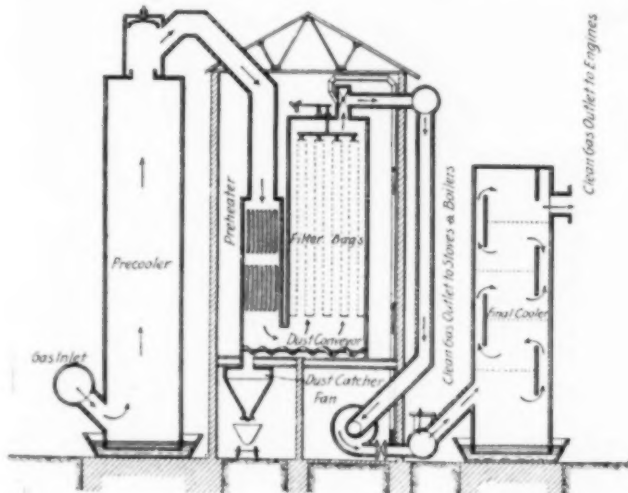


FIG. 25—HALBERGER-BETH GAS-CLEANING SYSTEM

A gas outlet, E, is provided in connection with the outer casing. The Körtzing injector is located at F and the feed water for same is supplied through the pipe G. The pressure is supplied by withdrawing a portion of the purified gas from the outlet pipe E and forcing this by the compressor K through the pipe H into the injector simultaneously with a stream of water.

FINAL DRY CLEANING

(Some of these systems can also be applied to primary cleaning.)

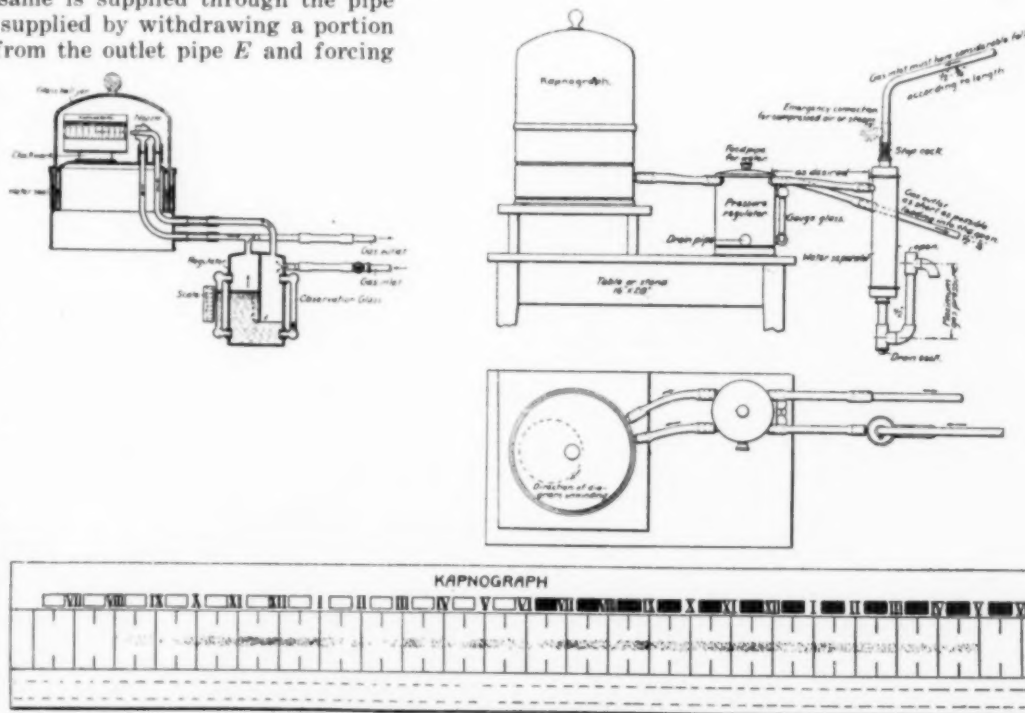
HALBERGER - BETH GAS-CLEANING SYSTEM

The principle of the Halberger-Beth system, shown in Fig. 25, is based primarily on filtering the gas through canvas bags. The gas coming from the blast furnace passes through the usual dust catchers and gas mains to a cooling tower, where the temperature of the gas is reduced to about 175 deg. Fahr. The cooling tower is arranged so that the necessary amount of cooling can be accomplished either by air or by direct contact with water, depending on the temperature of the gas entering the cooler, which temperature is naturally variable, in accordance with blast-furnace conditions.

From the cooler, the raw gas, by means of the suc-

tion of a fan placed beyond the filters, or without a fan when the pressure of the gas issuing from the furnace is sufficient, passes into and through the canvas filtering bags, depositing its impurities on the surface of the bags. These canvas filters are contained in a series of double compartments, each usually holding twelve canvas bags in rows of three by four. Each bag is about 8 in. in diameter by 9 ft. 9 in. long, and is equipped with a ring at each 18 in. of its length to prevent entire collapse of the bag when cleaning. The bags are fastened into a stationary header at the bottom, this bottom end being open, while the top is closed by a steel plate. Each bag is connected with a shaking mechanism located outside and above the filter compartment, and at regular intervals, usually about every four minutes, these bags are automatically shaken, a compartment at a time, for a period of from fifteen to twenty seconds. By means of a butterfly valve, the uncleaned gas is shut off from the compartment while the shaking is in progress, and cleaned gas, superheated to the proper temperature of about 175 deg. Fahr., is forced under pressure into the compartment. This causes a partial collapse of the canvas bags, which, in conjunction with the simultaneous shaking, allows the dust to fall from the canvas. The separated dust drops into a hopper beneath the sacks, whence it is transferred by means of a spiral conveyor to a bin, from which it is loaded into cars. At the end of the cleaning period the butterfly valve automatically returns to its original position and filtering commences again.

It is quite necessary to keep the temperature of the gas at about 175 deg. Fahr., as if much higher than



Specimen of strip indicating one day's run at a European Gas Engine Plant.

FIG. 29—THE KAPNOGRAPH

this there is danger of scorching the bag, while if lower the water vapor in the gas is deposited on the canvas and prevents proper filtration. In case the gas becomes cooled below 175 deg. Fahr. in the cooling tower, it is superheated by means of steam or by waste heat from the hot-blast stoves to about this temperature before entering the filtering bags. After leaving the canvas bags, the gas requires no further cleaning

for gas engines and is cooled down to the proper temperature in cooling towers of various designs.

The degree of cleanliness of the gas is indicated by the clearness of the effluent water from these towers and no settling basins are required. Consequently, this water can be used over and over again, which is a material item in districts where water is scarce. A further advantage lies in the non-pollution of streams, the laws relating to which are very strict in certain districts.

This system utilizes the basic principle employed in the "bag house" system, which has been used for the last twenty years in connection with recovering zinc

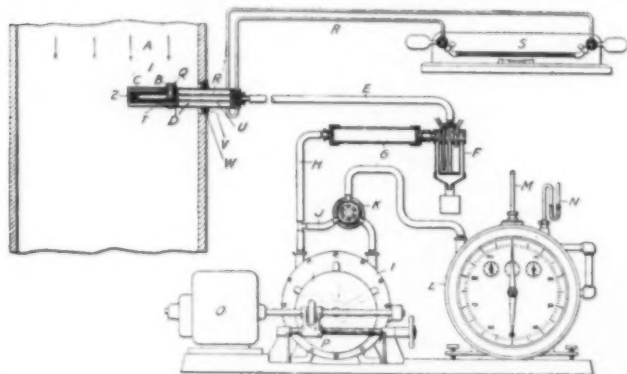


FIG. 30—THE BROWN DUST, MOISTURE AND VOLUME DETERMINATOR

dust from the gas issuing from zinc oxide furnaces and collecting dust from lead smelters.

THE KAPNOGRAPH

This instrument, shown in Fig. 29, continuously indicates the relative degree of cleanliness of the blast-furnace gas going to the gas engines, and is extensively used in European gas-engine stations. Gas from the cleaned gas main passes through this apparatus and impinges upon a continuous recording chart, upon which the dust in the gas is deposited. The variations in the amount of dust in the gas are indicated by

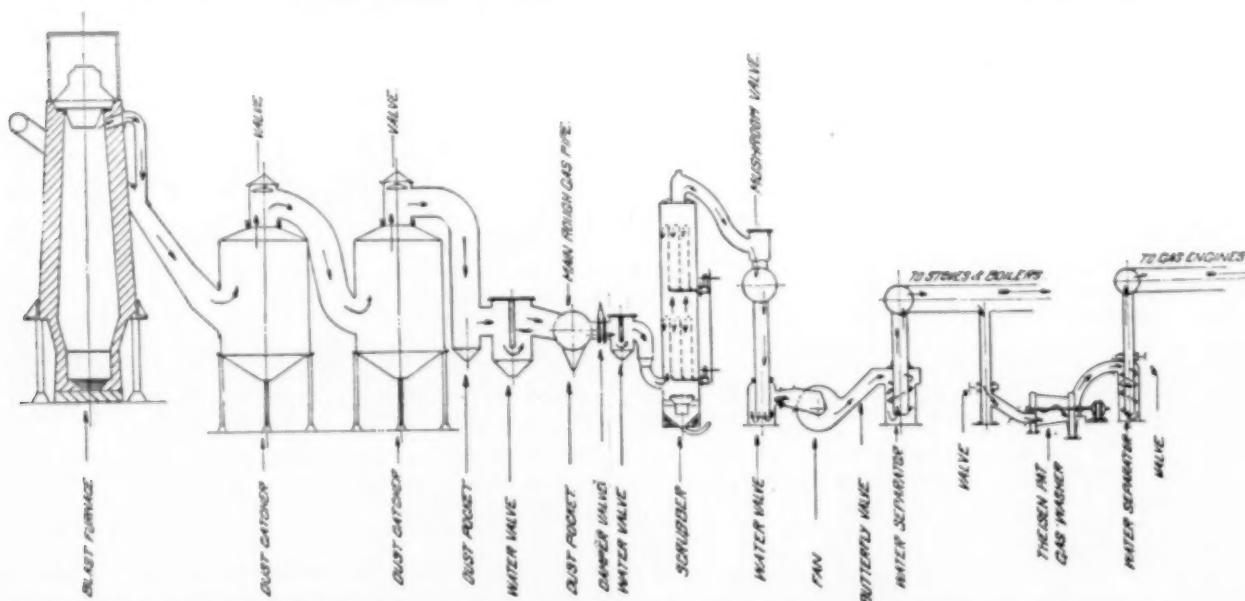


FIG. 32—THE COURSE OF THE GAS THROUGH THE CLEANING PROCESSES TO STOVES, BOILERS AND ENGINES

lighter or darker shades on the recording paper, depending on the amount of dust deposited. The flow of gas to the instrument is maintained either by the natural pressure of the gas, or, if this is not sufficient,

by an aspirator behind the outlet pipe. The speed of the gas to the nozzle is kept constant by means of a regulator, as shown in sketch, the excess gas over the required amount escaping into the outlet pipe by passing under a partition and through a seal of water.

METHODS OF DETERMINING THE AMOUNT OF DUST IN BLAST-FURNACE GAS

A method employed with good results in Europe for determining the amount of dust in the gas consists in drawing a definite quantity of the blast-furnace gas to be tested through a filter, which is weighed in a dry



FIG. 31—DUQUESNE GAS-CLEANING PLANT, SHOWING SCRUBBERS, WITH INTAKE FROM DIRTY-GAS MAIN AND OFFTAKE TO COLLECTING MAIN; ALSO SETTLING BASINS

condition before and after the test. The apparatus for determining the amount of dust consists of a glass tube drawn out at one end and fitted at the other with a ground-glass cover which is also drawn out to a thin tube. This cover facilitates the placing of the filter-

ing material in the tube, and during the test the cover is fastened to the tube by means of wire. Before the test, the glass tube, filled with suitable filtering material, is placed in a drying furnace and heated at a tem-

perature of 105 deg. C. until its weight is constant, which usually requires from one to two hours. The drying furnace is arranged so that several tubes can be dried simultaneously.

pipe through which samples of the gas are drawn. *C* is a filtering medium within which the solid constituents of the gas are deposited. *D* is a conduit leading to the exterior of the gas main through which the filtered gas is conducted. *E* represents a flexible connection to a surface condenser, *F*, *G* represents a receptacle for some chemical, such as calcium chloride, which can be used for the purpose of taking out the moisture contained in the sample. *H* is a conduit from this moisture-removing receptacle to the rotary air pump, *I*, or through the by-pass *J* to the three-way valve *K* and thence to the gas meter *L*, where the volume of the sample is determined, together with its temperature and pressure; these latter by means of the thermometer *M* and the U-tube *N*, respectively. An electric motor, *O*, is used to operate the pump *I* through the variable-speed drive *P*.

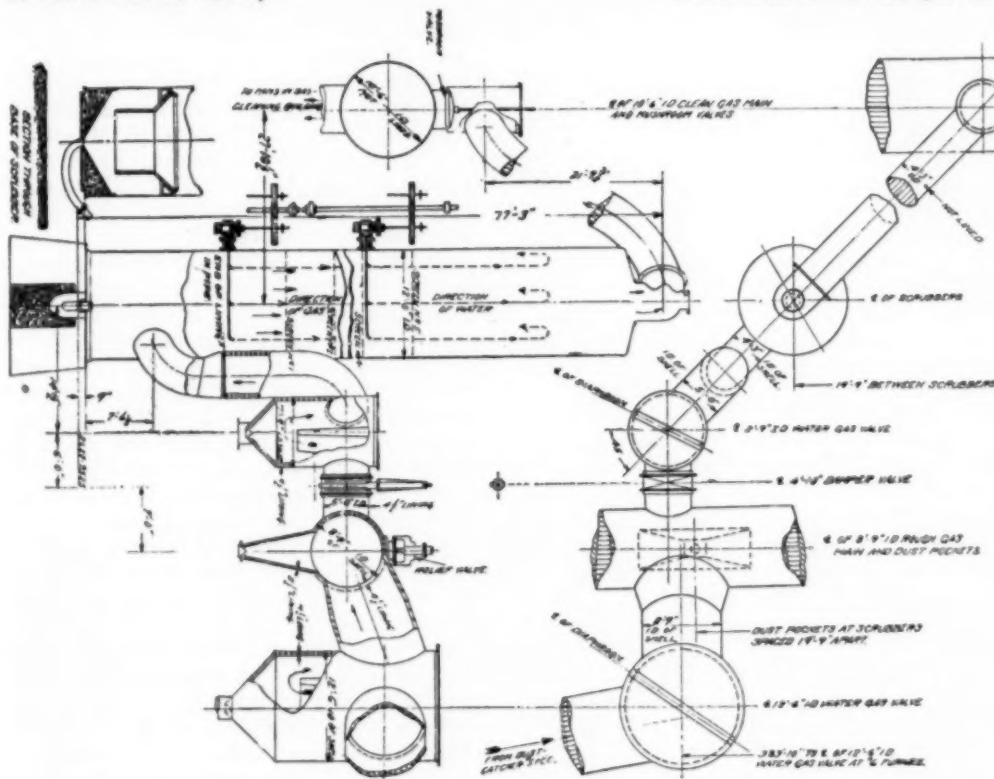


FIG. 33—SECTION THROUGH THE SCRUBBERS SHOWING THE METHOD AND APPARATUS FOR PRIMARY CLEANING. THE CUT-OFF VALVES ARE ON THE SIDE AND DRIVEN FROM A VERTICAL SHAFT

During the drying process air is drawn through the tubes after having previously been thoroughly dried by passing through bottles containing calcium chloride and concentrated sulphuric acid. During the drying process the tubes are weighed until no further increase in weight is observed.

In making the test, the weighed tube containing its filtering material is inserted into the gas main, a rubber stopper keeping the test-hole tight. The upper end of the tube is connected with a gas meter, which in turn is connected with a barrel filled with water. The water is allowed to flow out of the barrel and in so doing creates the necessary suction to draw the gas through the filtering tube and through the gas meter. When the necessary amount of gas has been withdrawn the tube is again dried and weighed. The increase in weight indicates the amount of dust in the quantity of gas tested.

BROWN DUST, MOISTURE, AND VOLUME DETERMINATOR FOR BLAST-FURNACE AND OTHER GASES

This apparatus has been devised in order to accurately determine the amount of dust and moisture contained in blast-furnace gas, as well as the volume of the gas, and is used with considerable success.

Referring to the accompanying drawing, Fig. 30, *A* is a gas main conveying the gas to be tested. *B* is an aperture in the small

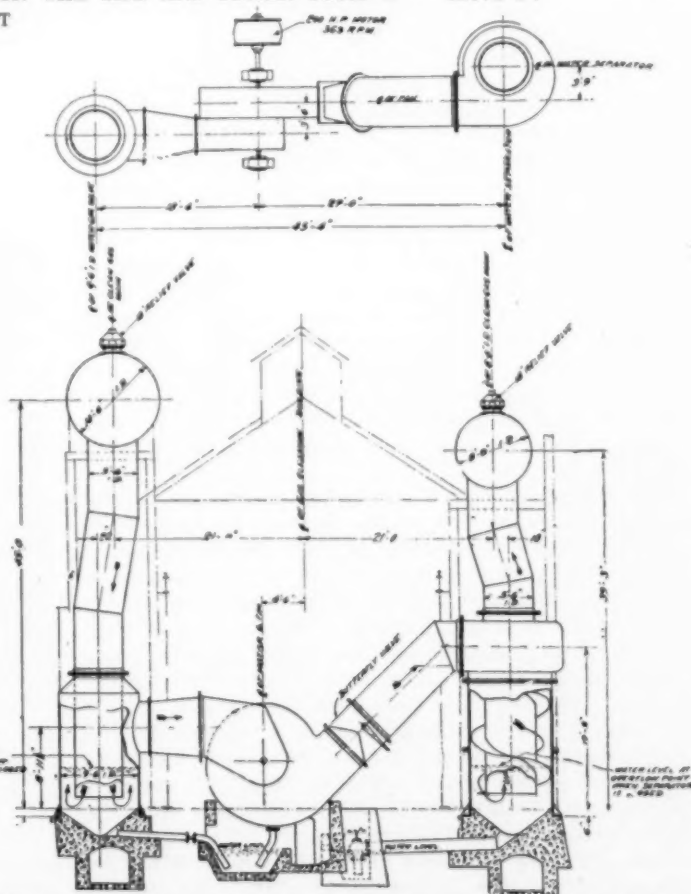


FIG. 34—SECTION THROUGH FANS, AND METHOD OF PASSING GAS THROUGH SEALS AND SEPARATORS

An indication of the velocity of gas or gases in conduit *A* is transmitted through aperture *Q* in the sample pipe and conduit *R* to horizontal pressure gauge *S*; also an indication of the velocity of gas or

tion is maintained for an indefinite length of time and the sample pipe is then withdrawn from gas main *A*. The meter reading, multiplied by the ratio of area of aperture *B* to area of gas main *A*, gives the total

amount of gas passing through gas main *A* in the elapsed time. The difference between the dry weight of the filtering medium *C*, before and after the test, divided by the number of cubic units shown by the meter, gives the weight of dust per cubic unit. The moisture per cubic unit of gas is found in a similar manner from the sum of the weights of the water in drying receptacle *G*, the water caught in the measuring flask attached to surface condenser *F*, and the weight of water retained in the filtering medium *C*.

Figs. 31 to 36 are reproduced from Mr. Diehl's paper as showing approved types of construction. The text of Mr. Diehl's concerns itself principally with operation and will be quoted in dealing with that subject.

In addition to the processes so clearly described by Mr. Forbes, there are various others designed to remove the dust from the gas in the dry state, but as these have had no extensive application for the blast furnace process, they may be omitted here.

Even since the time of Mr. Forbes' paper there has been an extensive development in Europe of the Halberger-Beth process of which there are now almost thirty plants in use in Europe and the number has been rapidly increasing. American furnacemen have been slow to take up this process and have acted in this matter along the same line as in many other cases; where an apparatus requires careful supervision or where its maintenance charges are high, operating economies secured by its

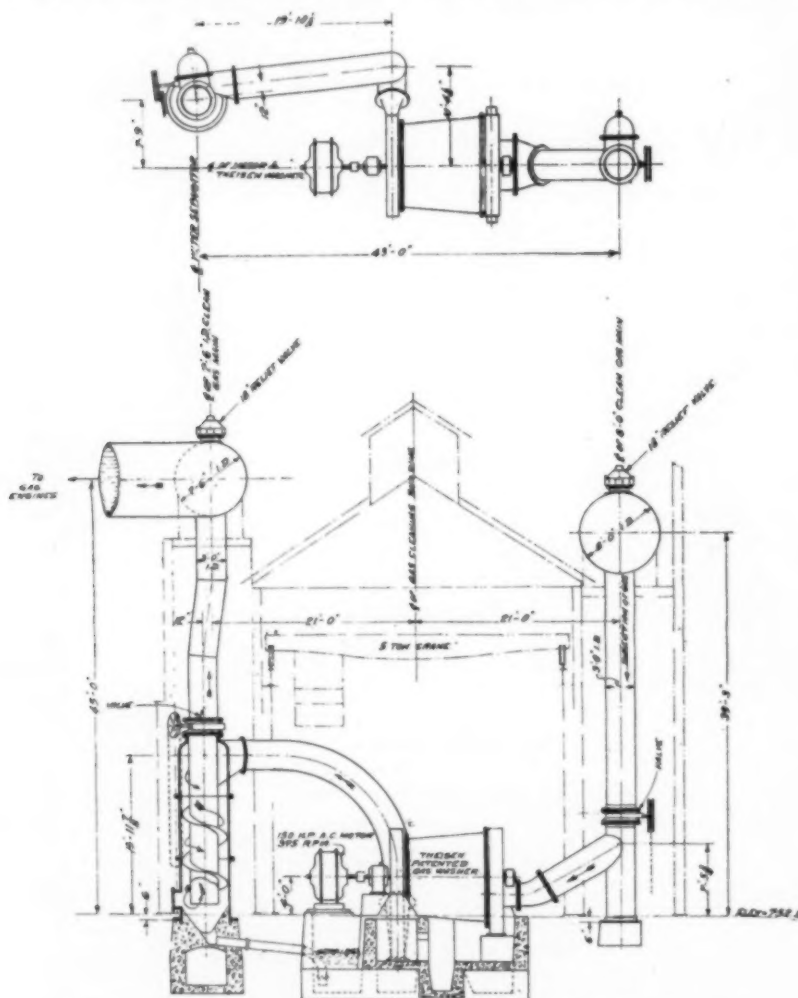


FIG. 35—SECTION THROUGH THEISENS, SEALS AND SEPARATORS

gases after passing aperture *B* is transmitted from aperture *T* through conduit *U* to horizontal pressure gauge *S*. It is evident that changes of the velocity of the gas or gases in aperture *B* of sample pipe, produced by the suction of pump *I* or by pressure in gas main *A*, are indicated, and can be accurately controlled and made equal to the velocity of the gas or gases in conduit *A*, the gas main, such indicator being the oil piston shown in glass tube forming a part of the velocity gauge *S*.

The method of operating this apparatus is as follows: The dry weights of the filtering medium *C*, of the receptacle *G*, containing the calcium chloride, and of the measuring flask attached to surface condenser *F*, are very carefully determined. They are then inserted in the apparatus, and the sample pipe is then inserted in the gas main, a tight connection being made between flange *W* and bushing *V*. The meter reading is noted. At the same time that the sample pipe is inserted in the gas main *A*, the time is noted, and the rotary pump *I* started. The speed is then so regulated that the oil piston in the horizontal pressure gauge *S* is maintained in equilibrium. This indicates that the velocity in aperture *B* is exactly equal to the velocity in gas main *A*, this condition having been determined by a measured amount of gas in gas main *A*, and the proper proportioning of aperture and conduits in the sample pipe during the calibration tests. This condi-

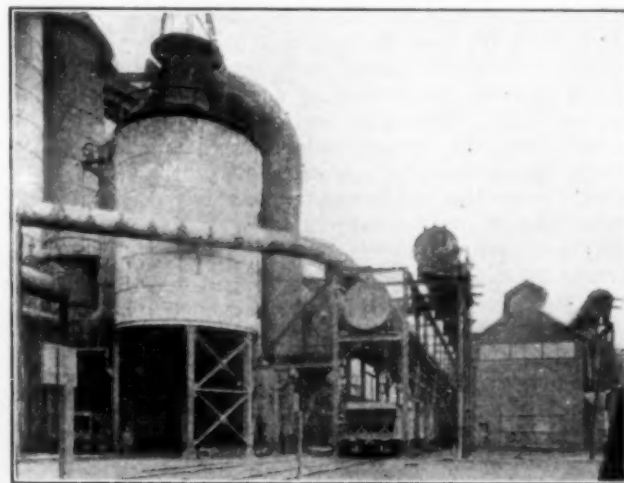


FIG. 36—DIRTY-GAS MAIN WITH CLEAN-GAS MAIN AT HIGHER LEVEL, ALSO THE END OF THE REFINED-GAS MAIN LEADING FROM THE THEISENS TO THE ENGINES

use are disregarded. The same has been true in regard to the gas engine, by-product coke-oven and many other kinds of apparatus.

This attitude is one often censured not only by for-

eigners, but also by Americans who do not consider all the aspects of such problems, particularly the financial one. The relative cheapness of capital and supervision and the costliness of raw materials in Europe as contrasted with the high cost of capital and supervision in America and the low cost of raw material constitute in no small measure a justification for the American attitude.

There is reason to hope that a process may soon be developed superior to either the wet processes or bag filtration plant and less complicated and difficult of maintenance. I refer to the Cottrell process for the electrical precipitation of the dust by a high-tension direct current passing through the gas column. This process has been developed to complete success in several lines of industry but its sponsors have hesitated to attack the blast furnace problem on account of its size and the complexity of the conditions. If this process shall ever be worked out to a commercial success it will furnish gas absolutely clean with no loss of temperature and with no increase in its moisture. These are the ideal conditions for the use of furnace gas for combustion purposes. For the gas engine it must in any event in present practice be cooled about to atmospheric temperature and this, of course, can easily be done after the gas is removed by a direct spray. Perhaps the time might even come if hot cleaned gas were available that the gas engine could be adapted to its use and thereby further increase its economy.

In conclusion it may be said that it is impossible at the present time to write a history of gas cleaning. The whole development of the subject in this country covers barely ten years in all and nine-tenths of it has been in the last seven or eight years. The advantages have become manifest and all furnacemen have sought a way rather than *the* way to clean the gas and undoubtedly they were right in this course for the plants installed early, even though not the last word of perfection in the subject, will have paid for themselves in bettered operating conditions before the much-to-be-desired best method is developed. It is possible, therefore, with this rapid development in progress, to give only an outline of the subject and to state briefly the principles which underly its application. To do this has been the attempt of the present article.

Treating Sulphurous Fumes at the Mammoth Smelter

BY AL H. MARTIN

The smelter and baghouse of the Mammoth Copper Mining Company are located at Kennett, Cal., a station on the Southern Pacific Railroad. Control of sulphurous fumes has been a vital problem practically since the commencement of operations, owing to the unfriendly attitude of the neighboring farmers and their complaints of alleged damage by smelter smoke. The baghouse system has been in successful operation about five years, and recent improvements have materially increased its efficiency. The baghouse system was first employed by the Mammoth Copper Mining Company, as relating to copper smelting, although its merit had previously been demonstrated at several lead-smelting plants, and has proved superior to the many contrivances tried in the Shasta field by other operators. Its efficiency is proved by the fact that the Mammoth is now the only smelter operating, while less than eight years ago three other plants also were in action.

The ores of the Mammoth mine are sulphides in the form of massive pyrites, with a large percentage of chalcopyrite. The average copper content ranges from

3 to 5 per cent, together with 4 to 5 per cent zinc and \$1.50 to \$2 in gold and silver per ton. The zinc is a valuable aid in neutralizing the sulphurous properties of the fumes, and gives no trouble in smelting. The blast furnaces are five in number, with three generally in operation. Each furnace has a tuyere dimension of 50 in. by 180 in. and has a capacity slightly in excess of 400 tons of charge per twenty-four hours. About three-fourths of this is ore, the balance consisting of silicious gold-bearing ore, lime and coke.

The fumes from the furnace hoods are led through steel goosenecks into two hopper-bottom brick flues. Each flue is 260 ft. long, and during the passage of the smoke large quantities of the dust settling from the heated fumes drop through the hopper bottoms into a brick-and-steel collecting chamber. From this chamber the fumes are passed into a compartment by means of four round steel pipes at the base of the former smoke-stack. These pipes are 100 ft. long and 8 ft. in diameter. The second chamber terminates in a flue 15 ft. square and 120 feet long. This guides the fumes into fan chamber which is of balloon-like shape, where the smoke is agitated and cooled by two Sirocco fans 11.5 ft. in diameter. Each fan performs 300 r.p.m. and is driven by a 400-hp electric motor. The fans not only cool the fumes but also serve to draw them from the furnaces and drive them into the baghouse proper.

Improved Arrangement of Cooling Pipes

From the fan chamber the fumes pass into the cooling pipes. There are fifty cooling pipes, arranged five to a section, each pipe having a length of 190 ft. with a 4-ft. diameter. The pipes are so arranged that the fumes pass for two-thirds of their length on a horizontal line, then emerge through a down-sloping section comprising a length of about 60 ft. Formerly the pipes were arranged in three sections. The fumes first passed through a sloping section, thence horizontally, and finally through the down-slanting portion. Tests proved better results were secured by driving the hot gases for a horizontal distance comprising two-thirds of the total length of each pipe. The complete system of cooling pipes embraces an area of 135,000 sq. ft., and the pipes have an aggregate length of 9500 ft.

The principal function of the cooling pipes is the reduction of temperature of the fumes to a point where they will not injure the woolen bags in the baghouse. The fumes have a temperature of 280 deg. C. at the fans, and this is reduced to 130 deg. at the discharge ends of the pipes, showing a loss of 150 deg. in the pipes. The fumes speed through the pipes at an approximate rate of 2700 ft. per minute and discharge into a distributing chamber. The fumes are still too hot for transmission to the bags and their temperature is reduced to 99.3 deg. by admitting cold air through the top of the chamber by means of twelve 24-in. pipes. A special fan supplies the cold air which serves to dilute the gases besides cooling them to the desired point. From this chamber the fumes pass into the baghouse through five short pipes.

The baghouse is 220 ft. long and divided into five bays, with four divisions to a bay. Each division contains 148 bags, or a total of 2960 for the complete plant. Each bag is woven of pure wool and is 34 ft. long with a diameter of 18 in. They are set 21 in. apart, center to center, and each five rows of bags is supplied with a hopper. The lower ends are secured to the floor and the upper edge suspended from vertical racks. The fumes enter the bags through their lower ends and filter through the woolen mesh, to finally escape through the five towers leading from the baghouse into the outer air. The wool catches the solids carried by the smoke and the bags are frequently given a vertical agitation

to shake the settled dust into the hoppers lying below. A special shaking device invented by J. E. Egleston is used, the apparatus being operated by electric motors. A wooden trough partly filled with water lies at the bottom of each hopper and the collected solids are drawn off into tanks and settled.

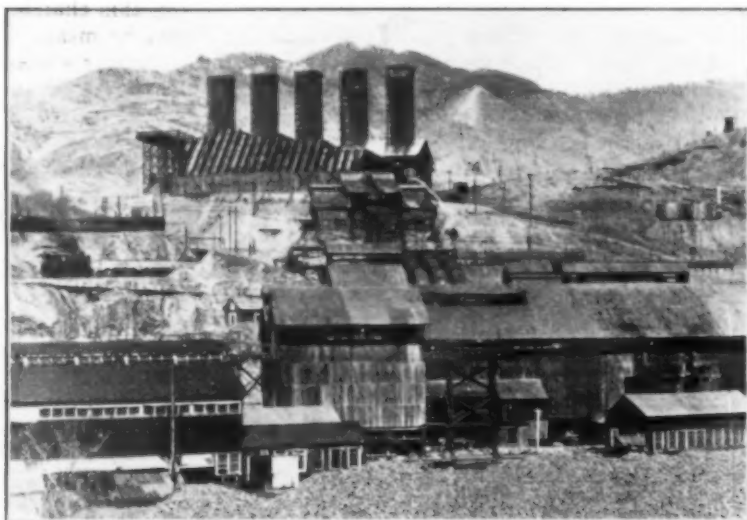
The baghouse is closed with the exception of openings along the sides of the floor and roof, and there is no way for the fumes to escape save through the five towers provided for that purpose. The openings along the floor and roof permit the free entry of large quantities of air to dilute the sulphurous acid gas (SO_2). The zinc sulphide is converted into zinc oxide in the blast furnace, and as zinc oxide has a natural affinity

the perfection of an economical process for recovery of the metals. Fully 16,000 tons of the whitish-looking dust is stored near the plant, and this amount is increased daily. It is estimated that the metals thus lost would pay for the operating costs of the baghouse system could they be recovered on an economical basis. G. W. Metcalfe is manager of the Mammoth Copper Mining Company, and J. H. Kervin superintendent of the smelter.

Chemicals Produced by the Aid of Electricity

According to the thirteenth census of the United States, in 1909 there were 34 establishments making chemical and metallurgical products by the aid of electricity, distributed as follows: Illinois, Maine, Maryland, Minnesota, Virginia and West Virginia, each, 1; New Jersey, 2; Pennsylvania, 3; Michigan, 5; New York, 18. Of the total value of products, New York reported \$13,401,878, or 72.6 per cent; Michigan, \$1,513,198, or 8.2 per cent; Pennsylvania, \$903,196, or 4.9 per cent; and all other states \$2,633,189, or 14.3 per cent.

The accompanying table shows the products and their value. The class "metals and alloys" includes aluminium, silicon, ferrovanadium, ferrosilicon, ferrotitanium, cuprovanadium, and other metals and alloys. Elements and compounds, produced by the aid of electricity specifically reported and included under the heading of "all other," are phosphorus, sodium, lead oxides, liquid chlorine, carbon disulphide, sodium carbonate potash and potassium bromide.



MAMMOTH SMELTER SHOWING BAGHOUSE AND COOLING PIPES

for sulphuric acid gas (SO_2), this noxious fume is thus neutralized. But to make doubly sure hydrated lime is introduced at the fans at the rate of 30 lb. per hour, effectively neutralizing any vestige of the fume that might resist the action of the zinc.

Pilot Bag Indicates Efficiency of Neutralization

That a constant test may be maintained to guard against any possible escape of sulphuric acid gas, the company operates a miniature woolen bag, about 2 ft. in length, in the distributing chamber. Should any acid escape, the bag would immediately be destroyed, and as long as the woolen fabric shows no sign of injury it is evident no acid is escaping. This test is maintained for the company's protection and forms a constant register of the efficiency of the practice, in case hostile agencies should claim to have detected traces of SO_2 in samples of the exterior air. Under normal conditions the volume of gas passing the fans is 333,000 cu. ft. per minute, and 100,000 cu. ft. of cold air is introduced per minute to reduce the temperature of the fumes. In hot weather it is necessary to use greater quantities of cold air, and the volume frequently reaches 125,000 cu. ft. per minute.

Tests of the smoke leaving the baghouse show that not a trace of dust or SO_2 escapes, and the volume of SO_2 is reduced 0.4 to 0.6 per cent, by volume, although the law permits the escape of the gas up to 0.75 per cent by volume. The dust precipitated in the cooling pipes, hoppers and flues contains considerable lead, zinc, silver, gold and other metals, but is of little use to the company as a satisfactory method of treatment has not been devised, despite numerous and extended experiments. A small amount is briquetted and returned to the furnaces, but the greater portion is stored pending

	Number of establishments reporting	Quantity, tons	Value
Calcium carbide	4	60,973	\$2,984,001
Caustic soda	5	19,428	1,032,647
Chlorates	5	5,785	904,550
Hypochlorites	5	45,976	1,506,831
Metals and alloys	9	.....	7,653,984
Abrasives and electrodes	4	.....	1,415,799
All other	11	.....	2,953,649
Total	34	.....	\$18,451,461

The most important class of products produced by the aid of electricity shown in the table as measured by value, is that comprising metals and alloys, which contributed 41.5 per cent of the total value in 1909.

An Acid-Proof Lining for Ore Vats.—In treating low-grade copper ore, one of the methods frequently employed is to dump it into large concrete basins and apply a 10 or 12 per cent solution of sulphuric acid. However, the difficulty encountered in this method is to get basins which will stand the effect of the acid. The usual procedure is to swab the interiors of the basins with an asphaltic mixture. The objection to this treatment is that the asphaltic coating is quickly destroyed by abrasion and has to be renewed at frequent intervals. Tests conducted recently in connection with the use of J-M acid-proof mastic, manufactured by the H. W. Johns-Manville Co., New York, for lining the acid basins, demonstrate that it is entirely successful in overcoming the difficulties heretofore encountered. Acid-proof mastic when laid $1\frac{1}{2}$ in. thick, forms a tough, impervious coating which is unaffected by acid and successfully resists abrasion. The basis of this material is a pure natural asphalt which will give years of service in ore vats.

The American Mining Congress will hold its next meeting at Phoenix, Ariz., December 7 to 11, 1914. Methods of safety and efficiency in mining will be considered, and federal aid to the industry.

Quantitative Blowpiping as an Aid to the Prospector

BY SIEGFRIED FISCHER, JR.

(Concluded from page 695 of November issue)

The Gold and the Silver Assay

In this treatise we will take the gold and silver together. It will be readily seen if only one of these metals is present, to what step the process should be carried.

Weigh out 100 mg (1.5432 grains troy) of the carefully sampled material and place it in the small horn scoop, taking care to brush all of the ore off of the scale pan. Ores containing large amounts of sulphur, arsenic, zinc, or antimony after weighing, need a thorough roasting before making up the charge.

Roasting.—Dr. Richards' improved method for roasting is superior to the one given in most of the textbooks, and will be the only one described here. It needs a little more care, but saves greatly in time. On a piece of charcoal a small cavity is made with the charcoal borer. The ore is carefully brushed from the scoop into this hole and spread out along the face of the cavity with the ivory spoon, so that it forms a uniform thin layer. A very weak oxidizing flame is then applied to it, paying particular attention that none of the small particles of ore are blown away.

After a while the material will have caked slightly and then a strong oxidizing flame is applied until no more fumes arise and no odor of SO_2 is observed. If this operation has been done carefully the material will have formed a cake which may be readily turned by carefully inserting a knife point at the edge and then turning. The turned side is then strongly roasted and after no fumes and no SO_2 odor is observed the sample is ready for the charge, brought back into the scoop and mixed with the necessary ingredients.

The charge will vary according to the ore, and it is difficult to give an absolute rule for making up this charge, but the following will about cover all purposes.

Borax-Glass.—The amount used depends upon the fusibility of the ore and upon the amount of materials to be slagged off. One hundred mg will usually suffice. If, however, the ore is hard to fuse due to large amounts of iron, cobalt or tin, more borax-glass must be added during the melting down of the charge.

Test-Lead.—As a general rule it is better to use too much test-lead than too little. The amount to be used depends on the amount of other metals present in the ore.

Ores carrying less than 7 per cent Cu or 10 per cent Ni use 5 Zentner (500 mg) test-lead per 100 mg ore. Anything above these amounts will be covered by using 20 Zentner (2000 mg).

Tellurium requires the same amount, i.e., 20 Zentners.

Speiss will use between 10 and 15 Zentners.

Ores containing tin will demand about 7 Zentners.

Sodium Bicarbonate.—This flux is mostly used for acid ores, and in small amounts where Cu is present. It forms easily fusible slags, it oxidizes iron and tin, which then pass into the slag, and acts also as a desulphurizer. The amounts to be used depend greatly on the nature of the ore and the function which the soda is supposed to perform. So it is nearly always used with ores carrying sulphur even though they were previously roasted.

A good all-around charge to use in connection with gold and silver ores is the following one:

Ore	100 mg
Test-lead	1500 mg
Borax-glass	100 mg
Soda	50 mg

The ingredients, after having been weighed out, or measured out, the test-lead in the particular measure, and the borax-glass and the soda in the ivory spoon (one spoonful = 100 mg), are brought into the horn scoop with the ore and thoroughly mixed, made up in the soda paper as previously described, and are then ready for the melting down.

Melting Down.—Near the end of one of the wide faces of a piece of charcoal bore a hole not too deep. Into this place the charge wrapped in the soda paper so that the bottom is toward the flame of the blowpipe and the side of the little package rests on the side of the cavity farthest from the tip of the blowpipe. Fig. 7 will make this clear.

Now apply a pure but not too strong reducing flame covering the total assay. This will carbonize the paper and melt the charge. When all is melted down, a strong reducing flame is applied. Most of the metals, and some united with sulphur and arsenic, will unite with the lead and melt with it to a button. Earthy materials as well as hard reducible metallic oxides and a small amount of the easily reduced metals melt with the borax to a slag.

To insure a complete collection of the lead, the charcoal should be kept in motion by turning back and forward. The lead should all be in one button and so should the slag. The latter must be in an easily fusible state. If slag is sticky and black, it shows basicity and borax must be added. If stringy and clear, the slag needs more soda. A good lead button should be white. If it is black, it still contains sulphur and must be oxidized. This is done by heating the lead button carefully with the tip of a fairly strong oxidizing flame. Lead oxide will go into the slag but no gold or silver.

This oxidation should continue until the surface of the lead button is light yellow, due to a thin layer of lead oxide. Do not heat too high or spattering will take place, causing a loss of values. When the button has the correct appearance, the charcoal is slightly inclined to insure total collecting of the lead melted, treated with a reducing flame, and the charge poured hot on the anvil. Usually only the lead will pour out, the slag remaining in the cavity. The lead on the anvil is hammered to a cube and is then ready for scorification.

Scorification.—This is done on a cupel. Fill the cupel mold with bone-ash, press the stamp down firmly and

give the stamp two or three sharp taps with the hammer. On removal of the stamp the cupel should be absolutely smooth. Place the mold in the holder, and grasp the wooden holder between the thumb and the index finger of the left hand, allowing the flat

bottom to rest on the bent little finger of the same hand. The cupel is then freed from moisture by heating.

When dry the small button is placed in the middle of the cupel with a pair of forceps. The cupel is slightly inclined towards the blowpipe, and a reducing flame applied to reduce oxides on the surface of the button until it is melted down. Then the assay is treated with a strong oxidizing flame.

Scorifying should be done quickly. The lead will form litharge which is partly absorbed by the cupel. Much of it, however, stays in the liquid form surrounding the ever-decreasing button. When the surface of the button as seen is about 3 mm in diameter the melt is allowed to cool.

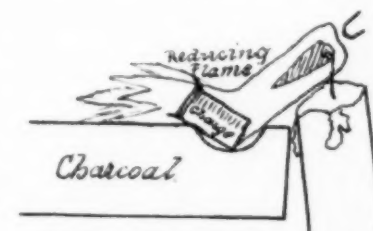


FIG. 7—ARRANGEMENT FOR MELTING DOWN

When set the mass is removed from the cupel, placed on the anvil, and the little button freed from litharge and bone-ash by hammering. It is good practice to clean the button by brushing with a glass or stiff-haired brush. The small, clean button is then ready for the fine cupellation.

Fine Cupellation.—Use a new, dried cupel. Place the little button on it so that it lies near the left edge. Incline the holder so that the little button cannot roll towards the blowpipe. Heat the button with a nearly vertical oxidizing flame until it melts.

When melted, take flame off the button and heat the bone-ash immediately surrounding it, rotating the holder with the two fingers so that the button will always come in contact with a fresh surface of bone-ash. The button will thus describe the path of a spiral toward the center of the cupel. The litharge will be absorbed by the cupel and, when the last trace of the oxide is removed, the button suddenly brightens. Then the operation is completed. This sudden flaring up is termed "brightening."

If silver alone is present this is the final operation and it only remains to weigh or measure the button. If the button is a large one it may be weighed, if small measured on the Plattner scale. *A large button may be flattened on the anvil, cut in half, each half put on cupel with test-lead brought down to new buttons and then measured on scale and weights combined.* The operation of measuring on the Plattner scale has already been described.

If the button is an alloy of silver and gold, then another operation is required, namely, parting.

Parting.—Under this term is understood the separation of the gold and silver. This is usually done by treating the button with nitric acid. The button is placed in a small porcelain dish. A drop of concentrated nitric acid is added to it and one or two drops of water. Holding the dish between thumb and index finger of the right hand, it is slightly inclined so as to have the button and acid in one place, and then gently heated over a flame. As the button is attacked, an evolution of heat will take place.

One cannot be careful enough here, because if spattering becomes very strong the small particles of gold will fly out of the dish. When the activity ceases, water is added. This is then carefully decanted, or, according to Dr. Richards, a small piece of filter-paper is so folded that it forms a fairly sharp angle. With the tip of this the solution is absorbed.

Wash again and repeat the treatment with strong nitric, washing finally twice.

This leaves the gold in a brown spongy mass. If the reaction was not too lively, all will be together. At times, however, the gold will be in several particles and these must be all collected. To gather the gold it is best to cut a small piece of test-lead from the solid piece, put it on the point of the forceps with the clean surface down, and then press this surface hard against the small gold particles. They will stay on this surface without difficulty and may be thus collected. This test-lead holding the gold is then cupelled to a button.

There is one thing which must be remembered, and that is, that not all alloys of gold with silver will be attacked by nitric acid. The button must have more than 50 per cent of silver. At the mint one-third gold to two-thirds silver is customary. If the button by its color shows that the gold predominates, then silver foil is added to make the ratio correct. The button, after having been weighed or measured to ascertain its total weight, is wrapped in the required amount of silver foil, folded into a small piece of test-lead and cupelled down to a button and then parted as before.

The final gold button is weighed or measured. If the

alloy was weighed, the difference between it and the weight of gold will give the weight of silver.

If it has been measured it will only give the volume and not the weight. All measurements on the ivory scale give the volume and the figures giving percentage or weight have been calculated from the volumes. As I am going to describe the use of Dr. Richards' scale it will be unnecessary to describe the procedure on the ivory scale as it is similar to Dr. Richards'.

In connection with this I would like to mention the use of Dr. Richards' scale. The button of the gold and silver alloy is dropped into the groove several times and the diameter noted. The mean of the maximum readings is used as the correct one. In the table that accompanies the instrument the weight of silver is found, if the button is all silver. Dividing this weight by the specific gravity of silver, 10.073, we obtain the volume of the alloy.

After the parting the gold button is also measured in the same way. Its weight is divided by the specific gravity of gold, giving the volume of the gold button. Both these volumes are in mm³.

Subtracting the volume of gold from the volume of alloy gives the volume of silver.

Multiplying the corresponding volumes by the specific gravity of gold and silver will give the corresponding weights of the two metals, from which the ounces or percentages can readily be calculated.

Scheme: Alloy $\frac{\text{mg silver}}{\text{spec. grav. silver}} = \text{volume of alloy in mm}^3$

gold $\frac{\text{mg gold}}{\text{spec grav. gold}} = \text{volume of gold in mm}^3$

Vol of alloy — vol. of gold = vol. of silver in mm³.

Vol. of silver \times spec. gravity of silver = weight of silver in mg.

Vol. of gold \times spec. grav. of gold = weight of gold in mg.

For conversion of mg into ounces see description of Plattner's scale.

Precautions in gold and Silver Assay.—If tellurium is not all eliminated it goes into the lead button and in final cupellation shows deleterious effects. It lowers the surface tension of the lead, causes it to spread out, forming separate globules, each of which contains some of the values. These small buttons cannot be collected. So it is essential to obviate this effect by adding enough test-lead to the initial charge.

It is essential that the little silver or alloy button be cooled slowly to prevent sprouting, due to the absorption of oxygen while hot which is liberated again immediately before cooling, causing a loss by spattering.

If during cupellation some bone-ash becomes loose it at times happens to collect on the button. When this occurs, take a little piece of test-lead, place it on the button and melt. It will melt together with the button, increasing the mass of same, and by inclining the cupel the button will liberate itself from the bone-ash.

If much copper is present in the assay one cupellation is not sufficient. More test-lead must be added to the button during the process and cupellation repeated until the button is free from all copper. If copper is still present after first fine cupellation the button will have a flattened appearance, and at times shows black spots of copper oxide.

The heating is another important factor in the fine cupellation. If the button is heated too high, silver will volatilize. If not high enough the litharge around the button solidifies and sticks to cupel. If this occurs, increase the intensity of the flame. The heating should be such that the litharge is absorbed rapidly by the cupel.

Removing the button from the cupel requires some care. To prevent the losing of the button it is always

advisable to work over a sheet of paper with edges turned up, thus forming a tray. When the button has cooled on the cupel it may be carefully pried loose from the same with the blade of a penknife, and then lifted out with the forceps, being sure that there is no pressure exerted which might change the shape of the small, nearly spherical granule. The button may also be removed from the cupel with the button pliers. One should remember always to handle it so that its form is retained. The button is then thoroughly cleaned from bone-ash by rubbing it gently with the tip of the finger on a piece of filter-paper, or with a brush.

The Copper Assay

In this operation it is desired to retain the copper in the melting-down process. If the ore contains sulphur, arsenic, antimony or zinc it must be roasted, after weighing out the sample. One hundred mg of the ore is used for the assay. This is mixed with 5 Zentners of test-lead and enough borax to make an easily fusible slag. Mix the ingredients of the charge and make up in the soda paper. Melt down on charcoal as previously described.

The slag should have a black appearance and show no red coloration. If red shows in slag, copper has been oxidized and must be reduced back to metallic copper by rolling the button around in the slag under the action of the reducing flame. Another method is to add a small piece of test-lead to the assay. This lead on melting, together with the button, will take up the reduced copper, and the process can continue.

If the borax sticks to the charcoal increase the heat of the reducing flame. When the charge is thoroughly melted down and all the metal collected it is poured on the anvil and hammered to a button.

Make a new hole in the charcoal and place button into it with crystallized boric acid. As this fuses harder than borax, a hotter flame is required. Melt first with reducing flame, and then oxidize. The lead forms an easily fusible lead borate of a greenish color. If there is any red indication it shows loss of copper.

To get copper out of slag, if any was lost in this manner, apply the reducing flame while rotating the button in the slag until the red coloration has disappeared. Loss in copper can be readily observed by the slag showing a sealing-wax red color in the light of the luminous flame.

The slag must always be kept fluid, and as long as this is done one may rest assured that the button is in a liquid form. When the slag commences to bubble, it shows that the maximum amount of borate possible has been formed. Any more heating will not aid the operation, but the charcoal will reduce some of the lead in the slag back to metallic lead.

When bubbling starts allow button to solidify, and while slag is still pasty remove the button with the forceps and immerse it in water, which is kept close in one of the small porcelain dishes. This immersion in water cleanses the button from adhering slag. Dry on filter-paper, place the button on a new place on the charcoal with fresh boric acid and oxidize carefully. Repeat this as often as required.

When the lead content gradually decreases, the button becomes harder and harder to fuse. The lead color disappears and the copper color takes its place. The melted button will assume a Nile-green coloration when copper is reached. On cooling the metal left will have a salmon color if pure.

If the button is finished it should be malleable, and when flattened out on the anvil it should show no cracks along the edges. If edges show cracks the button must be treated again with boric acid and newly tested. After assuring oneself of the purity of the metal button

it is weighed, and if the ore contains only the copper as values the operation is completed.

If gold and silver were also present in the ore, they will be contained in the copper button. After weighing this it is brought onto a cupel with test-lead and fine cupelled. This button will then contain the gold and silver, and is weighed or measured. Its gold content is then determined by parting, and the results interpreted as described under the heading of gold and silver.

With a little practice and care no hole need be bored in the charcoal for treatment with the boric acid. Simply place some crystals of boric acid on a flat surface of the charcoal and melt it down. Then place the button on the melted acid and treat it as above described. This method saves time and one has a better opportunity to observe what is taking place.

Cobalt and Nickel Assay

These metals as well as iron must be bound to arsenic to enable their qualitative determination. If copper is also present, it may be obtained as arsenide also. As a rule, ores carrying nickel will also contain cobalt and vice versa. The operation is based on the principle that when these metals occur together they may be successively oxidized out in the presence of borax, iron going first, then cobalt, nickel and copper.

Nickel, iron, cobalt ores not in the arsenide form must first be arsenicised. This is done by mixing 100 mg of the ore with 100 mg of powdered arsenic, wrapping the mixture in a soda paper, and placing the tightly and well-packed capsule in a test tube, heating this carefully in the non-luminous flame (alcohol lamp) at first, then increasing the temperature until the tube is red hot. The tube should be turned about its axis to prevent the charge in the soda paper from adhering to the glass. An arsenic mirror will form on the sides of the test tube, and when this does not seem to increase any more, the operation is completed. The charred paper containing the now arsenicized charge is then emptied onto the horn scoop ready for mixing with the other ingredients.

The method of procedure is as follows: Weigh out 100 mg of the ores, if needed arsenicise, if not mix directly with 50 mg of borax and 15 mg of soda, otherwise after arsenicising; wrap in soda paper, and reduce on charcoal until melted down, and metal collected in one button.

Now use oxidizing flame, and remove, first, the iron by continued oxidation in presence of fused borax. As long as iron is present the slag will show a distinct green coloration, and on allowing the button to cool it will show a black surface due to an oxidation product of iron and arsenic, probably a basic compound. If much iron is present the treatment with fused borax must be repeated, similar to the treatment of copper with boric acid. When nearly all the iron is gone the little globule of metal on cooling will be covered with iron oxide.

At last the metal button will show a metallic appearance. It is then removed, and after freeing it from the adhering slag, the button is placed on the charcoal without borax and treated with the reducing flame until no more arsenic is given off. The button is then free from iron and is weighed. One hundred mg-weight of button will give the amount of Fe,As.

The residual button is again treated with borax in the oxidizing flame. The slag now will show the cobalt-blue coloration. The button on cooling shows a pinkish iridescence. If much cobalt is present the treatment with borax must be repeated by removing the button each time, immersing in water and rubbing clean of slag, and then placing on charcoal with fresh borax.

As the operation nears completion and the cobalt is

nearly all eliminated, the pinkish color of the button disappears, the button is harder to keep melted.

When, on pinching some of the pasty slag between the platinum forceps and raising it slowly, it shows a purple color, and the button on cooling shows an apple-green tinge after all the cobalt is out. The button is cleaned and weighed. Then (100 mg — Fe_3As_2) — weight of button will give amount of Ni_2As .

If last weight is all Ni then the operation is completed, the weight of the button being then Ni_2As . But if the nickel left also contains copper, gold and silver then it is best to proceed as follows: Melt the button with about an equal amount of test-lead, and treat it with boric acid as in copper. The nickel is oxidized simultaneously with the lead with little or no loss. When the button shows the characteristics of a copper assay, it is weighed giving the weight of copper, gold, and silver. From here on the operation is similar to the assay of copper, gold, and silver alloys.

Precautions.—In heating always aim to have the slag in a melted condition, by melting button and then keeping the flame in the immediate neighborhood of it on the slag. It is far better for the novice to make a small cavity in the charcoal and to melt down in it, as it needs considerable skill to do the oxidizing on the surface of the coal directly. The button has a tendency to roll along the edge of the slag and unless carefully watched will roll off if not in a cavity.

The compounds formed and weighed are the following:

Fe_3As_2	52.8% Fe
Co_2As	61.1% Co
Ni_2As	61% Ni
$(\text{Cu} + \text{Ag} + \text{Au}) - (\text{Ag} + \text{Au}) = \text{Cu}$	
$(\text{Ag} + \text{Au}) - \text{Au} = \text{Ag}$	
100 mg — Weight of Co, Ni, etc., button	$\text{Fe}_3\text{As}_2 \times 0.528 = \% \text{ Fe}$
A mg — " " " " " "	$\text{Co}_2\text{As} \times 0.611 = \% \text{ Co}$
B mg — " " " " " "	$(\text{Cu} + \text{Ag} + \text{Au}) - \text{Ag} + \text{Au} = \% \text{ Ni}$
$(\text{Cu} + \text{Ag} + \text{Au}) - \text{Ag} + \text{Au} = \% \text{ Cu}$	
$(\text{Ag} + \text{Au}) - \text{Au} = \% \text{ Ag}$	

The example used is the most complicated one, including six metals.

If there was no iron present the first button obtained would be metallic in appearance and the slag would in all probability show slight losses of the metal present. A blue tinge would show cobalt and a smoky-brown tinge would show nickel. Great care should be exerted by the first melting down, to use a pure reducing flame so as to diminish possible loss. The color of the button is also a reliable source for judging what metal is on hand, pink indicating cobalt, white nickel.

Mercury Assay

The assay of mercury is very simple. 0.5 gm of the ore is weighed out, mixed with 1 gm of litharge and carefully brush into a glass tube about 19 cm long and 6 mm diam. This glass tube must be closed at one end and bent, as shown in Fig. 8C.

The glass tube is best prepared as follows: Take a glass tube about double the length required. Heat at the middle and draw out. The drawn ends will have a pointed appearance (Fig. 8A) and must be further heated and rounded off as Fig. 8B shows. One of the straight closed tubes is now bent about 2/3 back from the open end, by heating the desired place in a luminous flame while rotating the tube slowly. After a while the glass softens and the tube is readily bent to the desired angle. To prevent cracking it is well to keep the heated portion covered with the soot of the flame until cold.

Before putting the charge in the tube it must be heated so as to drive out the moisture, and prevent the charge from sticking in the straight part of the glass tube. The charge is best put into the tube by folding a card or slip of paper lengthwise, putting the

sample on it and shaking it carefully into the tube. Do not forget to brush the card free from any adhering particles. If some of the charge should stick to the tube a small camel's hair brush will serve to remove the particles. The actual charge is then followed by a good layer of litharge.

When the tube is ready for heating, the straight part of it should be absolutely clean. A loosely rolled piece of filter-paper placed on the mouth of the tube will take up any moisture from the charge. The closed end of the tube is then carefully heated. Slowly at first, because there may be moisture in the charge which on rapid heating would blow the litharge out of the bent into the straight part of the glass tube and spoil the assay. When all the moisture is out, the sample is heated until the charge is melted. The mercury will have sublimed and collected in metallic form in the straight part of the tube.

Allow to cool and take care to hold the straight part horizontally so that no mercury is lost.

Cut the tube with a file just at the bend, place on anvil and break off the part containing the charge. It is well at this stage to place a small porcelain dish under the open end of the tube, so as to collect any mercury, if it should roll out.

When the bent end has been carefully removed, tilt the glass tube over the porcelain dish and with a camel's hair brush attached

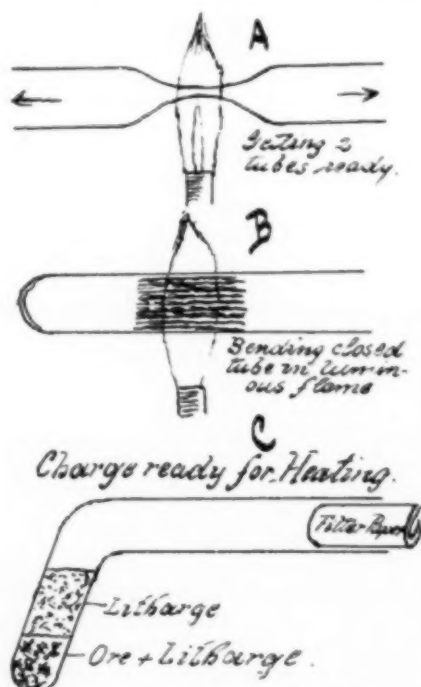


FIG. 8—ASSAY OF MERCURY

to a stick or piece of glass rod, brush the mercury into same. Before removing the brush, tap it sharply several times so as to cause any mercury sticking to it to fall into the dish. The globule of mercury should be clean and free from any litharge. It is then weighed, and gives the amount of mercury in the ore.

It is best to weigh the mercury wrapped in a weighed piece of paper to prevent it from amalgamating with the metal of the scale pan. This method may be used for all sulphide ores containing mercury, with one exception, namely, idrialite, a mixture of cinnabar, clay, gypsum, pyrites and bituminous matter which gives off volatile matter contaminating the mercury.

For chlorides the same charge is used with an addition of soda, the amount of this ingredient being three times that of the ore. The method of procedure is then the same.

Conclusion

There are further quantitative determinations possible, such as tin and lead, but these lack the certainty that those mentioned possess, and for this reason I will simply refer the reader to the book offering the best information on this kind of work: Plattner's Manual of Qualitative and Quantitative Analysis with the

Blowpipe, translated by Henry B. Cornwall and published by D. Van Nostrand Co., New York City.

It is of interest to know that by the aid of the blowpipe moisture determinations may be made as well as approximate coal analysis. These are, however, of less use to the prospector. To the jeweler quantitative blowpiping may be of use in determining the composition of alloys. But the main use of quantitative blowpipe work lies in the field of prospecting, as it is a quick and simple means of obtaining results, saving both money and time.

Finally I will cite a few examples showing the accuracy of the different methods. These results have been obtained by different individuals on the same ores.

Very rich silver ore, difficult to run:

Ag.....	2.43 mg.	worked in	1902
Ag.....	2.43 "	"	1903
Ag.....	2.45 "	"	1903
Ag.....	2.43 "	"	1904
Ag.....	2.44 "	"	1911

Gold, silver and copper assay:

Cu.....	22.0	Ag.....	24.2	Au.....	53.8	"	1906
Cu.....	22.0	Ag.....	24.2	Au.....	53.8	"	1912

Iron, cobalt and nickel:

Chloanthite:							
Co.....	10.8	Ni.....	13.2	"	"	1910	
Co.....	10.8	Ni.....	13.5	"	"	1910	

Garnierite ore:

Ni.....	6.1%	"	1896
Ni.....	6.0	"	1902
Ni.....	6.1	"	1914

Arsenic Speiss:

Fe ₃ As ₂	58.0	Co.....	7.9	Ni.....	7.7	"	1911
Fe ₃ As ₂	56.9	Co.....	8.0	Ni.....	7.6	"	1911
Fe ₃ As ₂	—	Co.....	7.9	Ni.....	7.6	"	1914

The inaccuracies here are not so much due to the method as to the lack of experience of the student, although in the determination of the iron there will always be more or less variation due to possible chances of losses in the operation.

Quartzose Cuprite and Bornite:

Cu.....	30.0%	worked in	1901
Cu.....	30.0	"	1903
Cu.....	30.0	"	1905

Azurite:

Cu (electrolytic).....	48.2%
Cu (blowpipe).....	48.1

Cinnabar from Malay Peninsula:

Hg.....	51.8%	"	1911
Hg.....	52.0	"	1911
Hg.....	52.3	"	1914

The most accurate results are obtained with the gold, silver and copper assays. For the others, especially iron, cobalt and nickel much more practice is required. Considering the amount of work the average prospector has done by the assayer to obtain information as to the possible value of his ores, one can readily observe that the time spent in acquiring these methods of procedure will soon pay, as the results are certainly close enough to give him positive information on the practical value of his ore—and that is what he is after.

Metallurgical Department,
Lehigh University, So. Bethlehem, Pa.

The Ohio Copper Company is in the hands of receivers as a result of voluntary and involuntary petitions in bankruptcy. The mine and mill near Salt Lake City are closed. Mr. F. Augustus Heinze, one of the principal holders of stock and bonds of the company, has protested against the proceedings on the part of the management, and has asked that the bankruptcy adjudication be vacated.

The first unit of the new mill of the Alaska Gold Mines Co., near Juneau, Alaska, is expected to be in operation in December, according to a statement attributed to D. C. Jackling, who has recently returned from a trip to the property. The rated capacity of the mill is 6000 tons per day, but it is stated that alterations in the original plans will make it possible to exceed this by one-third or more. It is expected that the entire plant will be in operation by the middle of 1915.

An Electrical Process for Detarring Gas*

BY F. W. STEERE

The object of this paper is to give a brief outline of the development of a commercial process for the precipitation of suspended particles from gas by high-tension alternating current, and the practical application of this process to the removal of tar from coal gas and from producer gas.

As the early experiments with high-tension discharges for precipitating suspended matter from gases have been reviewed quite thoroughly in recent articles by Prof. W. W. Strong, Dr. Cottrell, and others, only a brief mention of them will be made here. The phenomenon seems to have been first discovered as early as 1825, but very little, if any, effort was made to make practical use of it. From the first the precipitation of smoke seems for the most part to have claimed the attention of experimenters. The possibilities of separating gold, silver, and other metals carried in smelter fumes in a finely divided state, and the precipitation of acid fumes from smelters have also been fertile fields for inventors for years, the first patents having been issued as early as 1886.

The question is naturally asked why this method of purifying gases has not long since been in commercial use. Possibly the answer is found in the fact that although the phenomenon may be readily demonstrated on a laboratory scale with very simple apparatus, many

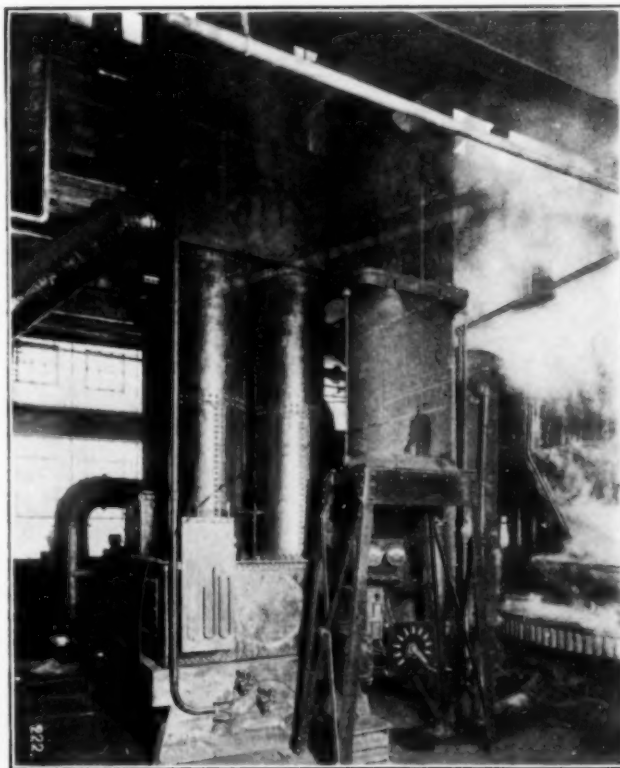


FIG. 1—ELECTRIC DETARRING APPARATUS FOR COKE OVEN GAS AT THE DETROIT PLANT OF THE SEMET SOLVAY CO.

serious difficulties were encountered in the various attempts to develop commercial apparatus embodying the same principles, but capable of continuous operation with little attention. A beautiful demonstration may be given with a hand-operated static discharging in a glass cylinder, or, on a larger scale, with an X-ray outfit discharging from wires suspended in ordinary piping, etc.

*A paper read before the American Gas Institute (New York meeting, October, 1914). Copyright, 1914, by American Gas Institute. Subject to Author's Corrections.

Such work, however, is hardly the first step towards the solution of the problem of a complete installation doing service and earning dividends 365 days in the year under the conditions found, for instance, in the ordinary gas plant.

The process recently developed by Dr. Cottrell shows what can be accomplished in precipitating dust. The Cottrell process consists in rectifying high-tension alternating current on rotating switches driven by synchronous motors, giving an intermittent unidirectional discharge. A plant using this process has recently been completed for precipitating the dust from the cement works of the Riverside Portland Cement Company, Crestmore, Cal., and according to recent reports is giving excellent results.

Herbert A. Humphrey seems to have been the first to use high-tension electric discharges to precipitate tar. Prior to 1897 we learn that Mr. Humphrey was using a static discharge within a small glass vessel through which he passed a known volume of gas, for making quantitative determinations of the tarry matter carried by the gas.

especially in those states having workmen's compensation laws.

By the use of alternating current the synchronous motors and rotating switches would be eliminated as well as the leads carrying the high-tension current from the transformer to the rectifier and from the rectifier to the electrode connections. Further, with the simple use of alternating current the transformer may be mounted on the ionizer, one terminal may be grounded and the other connected directly to the electrode terminal. With the terminals and connections completely inclosed so that no high-tension parts would be exposed, and with no moving parts requiring attention or inspection, the element of danger would be absolutely eliminated.

An opportunity was provided at the Detroit plant of the Semet-Solvay Company to work out these ideas and develop the theory on which this work is based. This theory, although far from complete, has proven sufficiently accurate to guide us in perfecting a detarring process which is in commercial use to-day.

In attempting to briefly outline the electrical action,

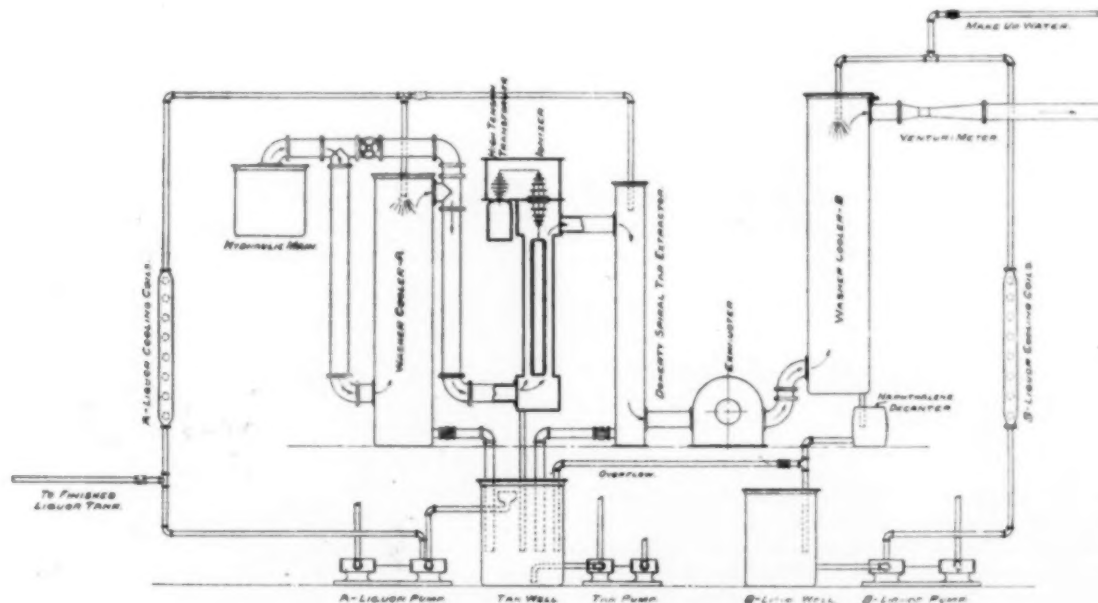


FIG. 2—DIAGRAMMATIC SKETCH OF THE EXPERIMENTAL PLANT FOR THE ELECTRICAL DETARRING OF COKE OVEN GAS AT THE DETROIT PLANT OF THE SEMET SOLVAY CO.

In 1911 work was started along these lines in the research laboratories of the University of Michigan at the suggestion of Prof. A. F. White. This work consisted for the most part in repeating the experiments of the early investigators and in attempting to apply the Cottrell process to the precipitation of tar from coal gas. The results of these preliminary investigations were given to the gas fraternity in a paper entitled "The Electrical Separation of Tar from Coal Gas," by A. F. White, J. W. Hacker, F. W. Steere, which appears in the *Proceedings of the Michigan Gas Association* for 1912.

The author, while engaged in this research work at the University of Michigan, became convinced that with a suitable arrangement of electrodes and apparatus, alternating current might be used instead of rectified current. The complications and difficulties of rectifying alternating current of from 40,000 volts to 80,000 volts on synchronous-motor-driven rotating switches will be readily appreciated. No gas man would relish the idea of having such an outfit as a part of his plant equipment to be looked after by the average operator,

we must keep in mind, first, that the gas molecules themselves possess both positive and negative electrical constituents which can be separated by X-rays, beta and gamma rays of radium, brush discharge from points, corona discharge from wires raised to high potential, ultra-violet light, etc. This process of separating neutral gas molecules into electrically charged parts or ions is called "ionization." It is outside the scope of this paper to attempt to discuss the ionic theory, but it should be noted that ions as such are very unstable and cease to exist, that is, recombine to form neutral molecules, almost the instant they are outside the ionizing influence. A very few molecules are continually splitting up, presumably because of the trace of radio-active substances found in most gases as well as in the atmosphere.

Professor Millikan, of the University of Chicago, has studied the movements of a small drop of oil between two oppositely charged condenser plates when attacked by atmospheric ions.* The drop received a charge when

* "The Oil Drop Method of Studying Electrical Phenomena in Gases," R. A. Millikan, *Trans. American Electrochemical Society*, Vol. XXI, 1912.

atomized, so by throwing on and off the electrical field, the drop is made to beat up and down between the plates. The instant an ion attaches itself to the drop the fact is made known to the observer by its change in speed, this change depending on the sign of the ion and the charge on the drop. The important and interesting thing to note is that with over a thousand drops studied in this way, the change of speed was always exactly proportional to the number of ions attached to the drop.

Let us recall that there were about twenty-seven billion molecules in 1 c c of ordinary air and that each molecule may be separated into at least two ions. When just one of the possible fifty-four billions ions per cubic centimeter attached itself to the oil drop it instantly caused an appreciable change in its velocity. Imagine then the violence with which this drop would have been thrown about if all the molecules surrounding it had been ionized.

This is just the condition we bring about in the electrical detarrer. The gas carrying the minute tar globules is swept into an intense ionizing field. Billions of gas molecules on every side are being torn apart. The resulting ions rush madly about in their effort to recombine. The unsuspecting tar globules find themselves in a storm center of unseen forces hurling them in every direction. The time occupied in the passage of the tar particles through the electric field is brief and it might naturally be supposed, as it heretofore has been, that an aimless to-and-fro movement of them would be the result of the applied energy. It would be hard to conceive of a condition more favorable to impact between tar particles, and experience shows that either because of this impact, or for some reason as yet unknown, agglomeration results and the dense tar mist is almost entirely dissipated leaving a relatively few large tar drops in its place.

This rather figurative description will seem more real to those who have witnessed this remarkable phenomenon within a glass vessel filled with dense fumes or fog. The instant the current is turned on, the whole field can

removing relatively large drops, and the electrical treatment simply converts the fine mist into the large drops.

A diagrammatic sketch of the experimental plant built at the Detroit Coke Ovens is shown in Fig. 2. The plant was not built complete as shown here at first, but was added to and altered as the work progressed. The course of the gas may be readily seen by referring to the cut. From the hydraulic main the gas passes either to a small washer-cooler A or by-passed this directly to the ionizer, depending on the temperature desired for the test. After the ionizer came the mechanical extractor, of which various types were tried. This apparatus was all on the suction side of the motor-driven exhaustor. Following the exhaustor was a second washer-cooler B, where the final cooling was effected. Measurements of the gas volume were made with a Venturi meter. The capacity of the plant was about 30,000 cu. ft. of gas per hour.

All work was done on the rich gas, that is, the gas given off during the first six or eight hours of the coking period. To insure complete recovery of ammonia and in other respects to duplicate as far as possible the condensing system used at the Detroit coke oven plant, two sets of cooling coils were used, one for cooling the circulating liquor from washer-cooler A and from the mechanical extractor when liquor was circulated through it, and one set for the circulating liquor from washer-cooler B. The make-up water was added to the B system and overflowed to the A system. When the A liquor was up to strength, it was pumped to the weak liquor storage tank.

Extensive use was made of the filter paper method of studying the condensed matter carried by the gas. This consists of aspirating a known quantity of gas through two thicknesses of filter paper, the resulting stain indicating relatively the quantity and to some extent the quality of the suspended matter. With the ordinary methods of condensing and cleaning, quantitative determinations by this method are unreliable, especially

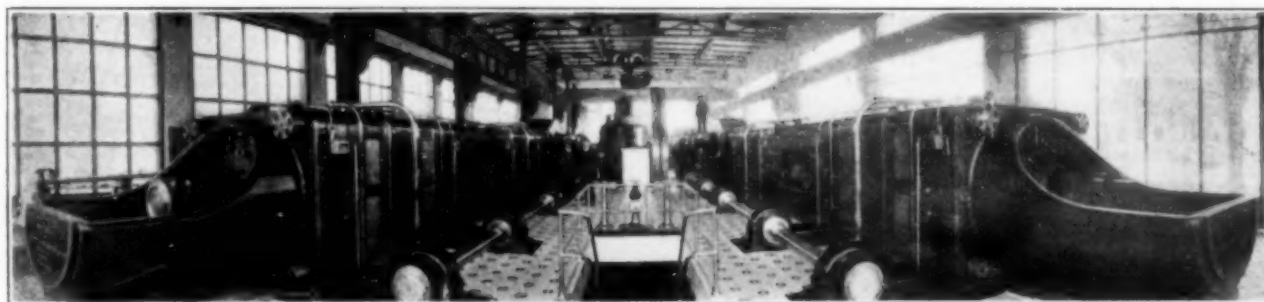


FIG. 3—LARGE GAS ENGINE AT FORD WORKS, OPERATED BY ELECTRICALLY DETARRER PRODUCER GAS

be seen to clarify. The commercial importance of this becomes more apparent when we realize that this action can be brought about at almost any desired temperature.

No attempt is made to free the gas of these agglomerated tar particles while it is still in the ionizing field. The apparatus is so arranged that everything is swept on through into some form of mechanical extractor where a complete removal is effected with very little power loss. The Doherty centrifugal tar extractor worked very well to accomplish this; the old type P and A machine also became a very efficient tar extractor when placed after the ionizer.

The whole process may be summed up in this: It is practically impossible to free the gas from tar in the extremely fine state of subdivision which naturally results from rapid condensation. There is no difficulty in

with producer gas, as an appreciable quantity of the very fine tar mist will pass readily through two thicknesses of filter paper. When the gas carries large quantities of tar mist, the aspirator bottle will be full of the dense brown fog which has passed through the papers. Over 1200 of these tests were taken in the course of this work and, although practically white papers were taken, we believe we have more reliable and conclusive evidence of the completeness of the detarring, which will be mentioned later.

The best results were obtained with the gas entering the ionizer at a temperature of from 65 deg. to 80 deg. C. (149 deg. to 176 deg. Fahr.). There was every indication, however, that with a gas not saturated with water vapor, the electrical action would be fully as effective at very much higher temperatures. Since this action is purely electro-mechanical in so far as it affects the tar,

the higher the temperature of ionization the more condensate will come down with the subsequent cooling. If the lower temperature condensate proved troublesome, a second treatment at a lower temperature could be used.

A very interesting development was the effect on the gasman's old enemy, naphthalene. Naphthalene by itself in the gas works, is quite a harmless and possibly valuable by-product. The trouble is all in the company it keeps; when mixed with enough tar to act as a binder, it is exceedingly troublesome, but when the tar is removed before the naphthalene condenses in appreciable quantities, the real cause of the trouble is eliminated.

This segregation was brought about as follows: Washer-cooler *B* was sealed in a barrel through a 3-in. pipe. The circulating liquor was drawn from the bottom of this barrel, cooled in pipe coils and returned to the top of the apparatus. It was found that with the foul gas entering the ionizer at about 70 deg. C. (158 deg. Fahr.) the naphthalene vapor was condensed in washer-cooler *B*, where the gas was cooled, and the crystals were carried out of the apparatus through the 3-in. pipe with the liquor into the seal barrel, and immediately came to the surface. The separation of the crystals and liquor even in this small vessel was almost perfect. After several weeks' run there was not the slightest indication of any deposit in the cooling coils or liquor lines. The gas was cooled in washer-cooler *B* to from 16 deg. C. to 25 deg. C. (60 deg. to 77 deg. Fahr.). Picric acid tests which were run to determine the naphthalene carried by the washed and cooled gas, checked invariably with the tables giving the theoretical naphthalene saturation at the observed temperature.

The whiteness of the naphthalene crystals recovered and the fact that there was absolutely no indication of any deposit in the coils or pipe lines, we consider proof conclusive of the complete freedom from tar.

Although at present naphthalene is a drug on the market it possesses so many of the characteristics of an ideal fuel for certain power purposes we are confident that it will become an important factor when there is a sufficient and dependable supply available. The farm tractor seems to offer an attractive field for investigation along these lines, especially in view of the success with which naphthalene is being used as an internal-combustion engine fuel abroad.

The two most valuable constituents of commercial light oil are benzol and toluol. The absorbing power of tar for these oils increases as the temperature decreases. With the tar as a fine mist the surface of contact between the tar and condensable hydrocarbon vapors is a maximum. It follows theoretically that if the tar mist is agglomerated to larger particles at relatively high temperatures the tendency for these oils to become absorbed by the tar is greatly reduced, and if this is followed immediately by a complete removal of the tar, this absorption of light oil by tar is reduced to a minimum.

Considerable work was done along these lines which undoubtedly establishes this theory within the range of our observations. Unfortunately we were unable to get gas above 80 deg. C. (176 deg. Fahr.), entering the ionizer, but analysis showed that the tar precipitated with the gas entering the ionizer at this temperature, contained but a trace of light oil, while the gas tested simultaneously, showed the highest light oil content. Light oil is, of course, not made by this process, but these experiments have shown beyond a reasonable doubt that the percentage of light oil carried by the gas and hence its illuminating power can be very materially increased. In coke-oven practice this has a dis-

tinued commercial importance with the increasing value of benzol as a motor fuel, and of toluol for use in the manufacture of explosives.

Cleaning producer gas for use in gas engines is one of the later developments of this process. Producer gas tar is very much more pitchy than coke-oven tar and the tar mist particles hardened at very much higher temperature. The tar mist carried by this gas when rapidly condensed, as is necessary in a compact plant, was found to be in such an extremely fine state of subdivision that a large per cent of the tar passed readily through two thicknesses of filter paper. It is this extreme fineness and relative hardness of the tar particles which makes the complete cleaning of producer gas by purely mechanical means a physical impossibility without an excessive power loss.

Arrangements were made with the Ford Motor Company, of Detroit, to try this process on the producer gas driving their large gas engines. At the outset many unlooked-for difficulties were encountered which required considerable time and study to overcome. Had it not been for the sportsmanlike attitude shown by Mr. Edward Gray, chief engineer and designer of the engines, in giving us every opportunity to study out these problems, we might have a very different report to make at this time.

The electrical process was eventually put in run at the Ford plant on Jan. 21, 1914, and up to this date has not been out of service one minute while the plant was running. All the difficulties which were in any way due to tar have been entirely eliminated. The regular operating force start up and stop the process with perfect confidence and at no time has it required any special attention.

In conclusion I wish to again call attention to the fact that this method of attack goes to the source of all the difficulties, that is, the almost molecular fineness of the tar particles which persist in carrying along with the gas in defiance of all mechanical scrubbers and washers. An enormous amount of time and study has been required to bring this process to its present stage, but notwithstanding the various difficulties, we now have in commercial operation a plant which requires no attention, is self-cleaning and is started or stopped at will by the regular operators.

The value of this electrical detarring process to the illuminating gas industry is as yet problematic, but it presents some very interesting possibilities. Its adoption would make possible a somewhat higher illuminating power with a given gas than is obtained from the same gas when the tar is removed in the usual way. By its use followed by a washer-cooler, tar-free naphthalene can be condensed and removed from the gas without causing stoppages in the condensing apparatus. The tar can be completely removed from the gas at any desired point in the gas condensing and scrubbing system; the complete removal of tar, prior to condensing gas, will make a relatively clean weak liquor possible. For the by-product coke-oven industry the process promises to be of value in connection with the direct method for the manufacture of ammonium sulphate, as well as for its possibilities as a means for recovering naphthalene and increasing the yield of benzol and toluol.

The commercial plant for detarring producer gas which has now been in continuous and successful service at the Ford Motor Company for several months has demonstrated beyond all doubt the value of the process for this branch of the industry. With these possibilities it seems not unlikely that this process may eventually play an important part not only in cleaning producer gas, but also in the manufacture of coal gas.

Detroit, Mich.

Note on the Preparation of Pure Calcium Carbide

BY M. DEKAY THOMPSON

EXPERIMENTS BY L. R. GONZALEZ AND K. B. BLAKE

In the reaction according to which calcium carbide is prepared technically, $\text{CaO} + 3\text{C} = \text{CaC}_2 + \text{CO}$, the carbide is necessarily contaminated by the presence of lime and carbon, and it is not possible to remove these impurities.

A number of methods of making calcium carbide in the pure state have been described, but in attempting to follow directions for the purpose of making pure calcium carbide for experimental purposes, difficulties were encountered which were not mentioned in the papers describing these methods. Our experience with the different methods that looked promising are given below.

THE ACTION OF PURE CARBON ON METALLIC CALCIUM

The first method tried for producing pure calcium carbide is the action of calcium on finely divided carbon, as described by Moissan¹. According to Moissan this synthesis takes place at a low temperature and can be produced by heating a mixture of carbon and calcium in a porcelain crucible over an alcohol lamp. The heat evolved fused the carbide.

The calcium used in our experiments was furnished in the form of a rod about two inches in diameter, and was evidently made by the Rathenau² process.

Turnings were made from this rod in a lathe, keeping the metal covered with a film of kerosene during the operation. The turnings were kept under petroleum ether. It was analyzed by dissolving a weighed portion in water and titrating with standard hydrochloric acid, using methyl orange as an indicator. Any sodium or magnesium present would be counted as calcium. Magnesium and iron were shown to be absent. The purity found by this method was 98.17 ± 0.01 per cent.

Carbon was prepared in three different ways. (1) Sugar was added to sulfuric acid, causing carbon to separate in a spongy mass. Some sulfuric acid was reduced to sulfur dioxide, which was recognized by the odor. The mass was washed, dried, ground up, and boiled in caustic potash for several hours, and then in successive portions of water until the sulfate was entirely removed. This was then dried and ignited at a dull red temperature for one hour.

(2) Carbon was made by allowing acetylene to burn with a smoky flame and the soot collected on a copper vessel filled with water. Acetylene was generated from commercial calcium carbide and was purified³ by passing in succession through a concentrated solution of chromic acid in sulfuric acid, a saturated solution of lead nitrate, and finally through a drying tower containing a layer of bleaching powder below a layer of calcium chloride. Ten grams of carbon were prepared by this method, which after igniting had a bluish tinge.

(3) The third method consisted in burning granulated sugar, grinding to powder and washing free from caramel. This was dried and ignited at a dull red temperature for half an hour in a covered porcelain crucible. This product had a shiny black color.

Equivalent quantities of calcium turnings and carbon made from sugar and sulfuric acid (2.156 gr. Ca, 1.275 gr. C.) were mixed in a porcelain crucible. The crucible was heated by a Tirrell burner for five minutes, but the desired reaction did not take place. The calcium had oxidized. Another similar sample of

calcium and carbon was heated in the blast lamp. After two minutes the reaction took place with violence, breaking the crucible. The contents were incandescent. Two portions of carbide were made in this way. It was of a greyish brown color and was hard and porous. The part in contact with the crucible was not collected. The rest was analyzed by the loss in weight method of Bamberger⁴. It was found to be 62 per cent. carbide. On boiling the sodium chloride solution in which the carbide was decomposed, after the addition of a little caustic soda, a strong odor of ammonia was noticed, showing that at the high temperature of the reaction, some calcium nitride had been formed.

Evidently, therefore, pure calcium carbide in any appreciable quantity cannot be produced by the direct action of carbon and calcium.

THE ACTION OF CARBON ON CALCIUM HYDRIDE

The production of calcium carbide by the action of carbon on calcium hydride is also described very briefly by Moissan. The hydride was made by heating calcium turnings in an atmosphere of hydrogen in a nickel boat in an electric tube furnace. Ten grams of calcium was the largest amount used at one time⁵. The absorption of hydrogen by calcium started from 220°C . to 250°C . The temperature was gradually raised to 900°C ., and held there until no more hydrogen was absorbed.

Eight separate portions of hydride were made; the first was pure white; the others were grey. In some cases the calcium alloyed with the nickel boat and had to be discarded. The hydride was crystalline and easily powdered. It was ground up and thoroughly mixed with an equivalent weight of carbon made from sugar and sulfuric acid. This was heated in the electric tube furnace.

The reaction which takes place is the following: $\text{CaH}_2 + 2\text{C} = \text{CaC}_2 + \text{H}_2$. The hydrogen was removed by a Richards pump and the pressure kept at about seven millimeters of mercury. The product obtained after several trials appeared white to the naked eye. When examined under the microscope the main part was seen to be white and transparent, except for crevices between the crystals which were apparently filled with uncombined carbon.

The analysis gave 103 per cent carbide. The cause of the apparent excess was found to be the presence of hydrogen sulfide, which was weighed as acetylene. The sulfur doubtless came from the sulfuric acid used for carbonizing the sugar. This shows how difficult it is to remove all the sulfur from carbon made in this way. Probably some of the acid is reduced to sulfur by its action on sugar.

The reaction between the hydride of calcium and carbon appears to begin at 50°C . as shown by the evolution of gas, which becomes rapid between 110° and 125° . This may, in part, be occluded gases of the carbon. The reaction appeared to be complete at 940°C .

The action of carbon made from acetylene on calcium hydride was next tried. The hydride was ground and passed through a sieve with 140 meshes per linear inch; 11.07 grams of this hydride were mixed with 6.292 grams of carbon by grinding the two together. One-third of this mixture was taken for a charge. This was placed in a nickel boat and heated in the tube furnace. The air was washed out by hydrogen before heating. On heating this mixture evolution of gas began at 30° as in previous runs, and continued as

¹C. R. 127, 917-18 (1898).

²Z. f. Elektroch. 10, 508 (1904).

³Thorpe, Dic. of App. Chem., Vol. 1, p. 25 (1912).

⁴Z. f. angew. Ch., 1898, 196.

⁵Moissan gives 15 grams as the upper limit. More metal may cause the temperature to rise to be sufficient to alloy the calcium and nickel. C. R., 127, 29 (1898).

the furnace was heated to 1200°. (This was the temperature at the middle of the furnace; the ends of the boat may have been one hundred degrees cooler.) Even after holding the temperature at 1200° for an hour the evolution of gas still continued.

The furnace was cooled without waiting for the gas evolution to be complete, and the charge examined. Except for a discoloration, the charge appeared unchanged; it did not react with water, and under the microscope the crystals of hydride could be seen, surrounded with the finer carbon. This showed that for some unexplained reason the carbon from acetylene does not react with calcium hydride to form calcium carbide.

The evolution of gas must be explained some other way. It may have been gas that was occluded in the carbon to start with or possibly the subcarbide⁶ of calcium may have been formed: $\text{CaH}_2 + \text{C} = \text{CaC} + \text{H}_2$. The subcarbide does not react with water, but still this explanation does not seem probable.

The action of carbon made by heating sugar was also tried on calcium hydride. When mixed in equivalent quantities and heated in an electric tube furnace to 1000° C. in a vacuum, the product contained 28 per cent carbide. With a more intimate mixture the product contained 41.3 per cent carbide.

Pure calcium carbide cannot therefore be made in quantity by the action of carbon on calcium hydride.

THE ACTION OF ACETYLENE ON CALCIUM AND CALCIUM HYDRIDE

When fine turnings of calcium were exposed to acetylene gas in a porcelain tube furnace at a temperature as high as 750° C., carbide was produced only on the surface of the turnings. The action of acetylene on calcium hydride was even less than on calcium.

THE ACTION OF ACETYLENE ON CALCIUM DISSOLVED IN LIQUID AMMONIA

Finally Moissan's method⁷ of passing acetylene into a solution of calcium in anhydrous liquid ammonia was tried. On passing acetylene into the blue solution the white precipitate described by Moissan consisting of $\text{CaC}_2 \cdot \text{C}_2\text{H}_2 \cdot 4\text{NH}_3$ appears and the solution loses its color. More calcium is then added and this may be continued until the required amount of carbide is obtained. (If the calcium is added to liquid ammonia in larger quantities a lustrous golden brown paste is formed.)

This carbide, however, is very reactive, due to its fine division, and the moisture of the air acts on it with such violence that the acetylene produced takes fire. According to Moissan the acetylene and ammonia are driven off at 150° C.

This method of preparing pure calcium carbide is, therefore, the only one of those tried that seems suitable for yielding it in sufficient quantity for experimental purposes. There is no difficulty in handling it as long as it is moist with ammonia. In introducing it into an electric vacuum furnace, for example, it would be necessary to have it covered with ammonia.

Some of the paste made by dissolving a large amount of calcium in liquid ammonia was allowed to stand in an atmosphere of acetylene. It gradually changed over into a grey powder which did not take fire in the air, and could be transferred to the furnace without any protection.

When heated to 150° it yielded a fine white powder, which when it was treated with water evolved an odorless gas.

⁶Erlwein, Wart, and Beutner, Z. f. Elek. 17, 177 (1911).
⁷C. R. 127, 911-17 (1898).

SUMMARY

Experiments are described, the object of which was to find a suitable method for making pure calcium carbide in quantities large enough for experimental purposes. The reactions between the following substances were not found to be suitable: carbon and calcium; carbon and calcium hydride; calcium and acetylene; calcium hydride and acetylene. The action of acetylene on calcium dissolved in anhydrous liquid ammonia was found to produce the desired result.

Electrochemical Laboratory,
Massachusetts Institute of Technology.

Radium for the Masses

A Western assayer and chemist has received an important document from a genius whose letter-head announces that he is a dealer in "Dry Goods, Groceries, Hardware, Queensware." Evidently his activities are broader than indicated by his business, and scientific ability is being wasted in dry commercial pursuits. We quote *verbatim* from the letter:

Dear Sir,
I wish to take up small amount of your time to inform I have way to extract Radium from carnotite ore and get more out of it than heretofore.
If your in position to send me 5 or 10 pounds of your ore from your state I will extract it and send you the Radium free of cost I want to find how rich your ore is by that way hoping to her of you.

Yours Respectfully

Let the Bureau of Mines look to its laurels!

Laboratory Apparatus and Reagents Catalog.—The Arthur H. Thomas Company, of Philadelphia, Pa., has just issued its handsome new catalog entitled Laboratory Apparatus and Reagents, selected for laboratories of chemistry and biology in their application to education, the industries, medicine and the public health, including some equipment for metallurgy, mineralogy, the testing of materials and optical projection. It is a handbook of 660 pages, and embodies some really important novel features, particularly in the Reagents' Section. The first and by far the largest section deals with laboratory apparatus on 585 pages, brief, concise, illustrated descriptions being given of more than 12,000 different pieces of apparatus. The general arrangement is alphabetical, but in view of the mass of material described, a special alphabetical index of twenty pages at the end of this section is by no means superfluous. The reagents' section is the second section of the catalog and comprises seventy-four pages. In it 2300 different chemicals are listed alphabetically. The outstanding feature is that in the case of the chemically pure chemicals of Baker, Kahlbaum and Merck, the "typical analysis" of Baker, the "certified analysis" of Kahlbaum and the "guaranteed analysis" of Merck are given respectively, which facilitates greatly the selection of the most suitable brand in each case. The prices listed are the prices before the war started, and indicate, at least, the normal price basis for the reagents.

The Miami Copper Co. has officially announced the passing of the regular quarterly dividend payable November 16, 1914, due to conditions of the world's business and finance and the necessity of conserving the company's resources. The Boston News Bureau estimates that the passing or reduction of dividends by copper companies has caused a loss to investors at the annual rate of nearly \$29,500,000.

Production in the Cobalt district increased in September as compared with August, and is now about normal. Temporary curtailment in August was due to uncertainty regarding the silver market caused by the war.

Synopsis of Recent Chemical and Metallurgical Literature

Copper, Lead and Zinc

Electric Furnace for Melting Cathode Copper.—The adaptability of the electric furnace to melting, refining and finishing purposes, and the disadvantages arising from the use of the reverberatory in melting cathode copper, have led Messrs. D. A. Lyon and R. M. Keeney to consider the possibility of electric melting of this material. Their original paper appears in the August *Bulletin* of the A. I. M. E. It is shown that so-called reverberatory refining of cathode copper results in deterioration of conductivity as compared with electrolytic copper which has not been melted, due to the introduction of impurities during melting. The ideal method would be one in which cathode copper would be melted and cast into marketable shapes without absorbing impurities. This would require a neutral process of melting such as could be done in an electric furnace. The authors discuss the types of furnace that might be used: (1) induction; (2) resistance; (3) direct arc; and (4) indirect arc. The conclusion is reached that the most practical furnace for copper melting would be the direct-arc type having a non-conducting hearth, like the Heroult steel furnace. In order to reduce possible volatilization to the lowest point it would be necessary to keep the metal covered with a slag while current is passing through the furnace. It is estimated that the power consumption would not be over 300 kw-hr. per ton of copper melted. Using this figure and basing other expenses on electric steel practice, the cost of melting cathode copper in a furnace of 25 tons capacity per charge should not exceed \$4.75 per ton, or 0.238 cents per pound, of copper melted, with power at $\frac{1}{2}$ cent per kw-hr.

Fuel in Reverberatory Copper Smelting.—A valuable record of experimental work in reverberatory smelting is contained in the paper of Mr. C. D. Demond in the August *Bulletin* of the A. I. M. E. Experience with various fuels at Anaconda is given in detail, showing the requirements for a satisfactory reverberatory fuel. Four factors in coal affect smelting efficiency: 1, the character of the true coal substance; 2, the percentage of fine; 3, the percentage of moisture; and 4, the character and percentage of the ash.

In judging the character of the coal from proximate analysis a good deal of caution must be used, for the figures may be very misleading as to the ratio of fixed carbon to volatile matter in the real coal, and nothing can be told regarding the composition and quality of the volatile matter. Coal giving an opaque yellow or white flame due to incandescent particles is essential for success in reverberatory work. An excessively dense or smoky flame is not desirable. With coals that do not flame well under natural draft there may be a marked improvement under forced draft.

Furnace results are directly affected by the quantity of fine in the coal, the ratio of charge smelted to coal burned falling with the increase of fine coal. The best solution of the problem of fine coal is to pulverize all the coal and burn it by blowing directly into the furnace. This practice is growing in favor and has been adopted at some plants.

Moisture in the coal requires heat for its evaporation, and reduces the temperature of the furnace. The percentage reduction of the margin above the critical temperature reduces the capacity and economy of the smelting operation.

Ash also reduces the heating value of the coal, but has a value in preventing excessive loss of fuel through the grates. In some cases, however, the ash

may clinker so badly as to clog the grate and interfere with combustion. It is seldom possible to predict from an analysis of the ash what its clinkering qualities will be.

Other factors affecting the efficiency of reverberatory smelting are the fluxing of the charge, preheating the charge and preheating the air. Mixing lime-rock flux with the calcine before charging to the reverberatory as against charging calcine and flux separately, has resulted in increasing furnace performance from 144 tons smelted with 46 tons of coal to 163 tons smelted with 48 tons of coal. Charging the calcine mixture hot also results in increased economy. Preheating the air in efficient heating devices has resulted in some cases in increasing furnace capacity 50 per cent over that obtained with cold air. The production of steam with waste heat from reverberatories at Anaconda makes about 25 per cent of the heating value of the total coal effective, while only 15 per cent is actually utilized for smelting. Power thus developed from eight furnaces amounts to 30 per cent of the 16,700 mechanical horse power used in the entire smelting and concentrating plant.

Sinter-Roasting Processes Compared.—A comparison of the Huntington-Heberlein and Dwight-Lloyd processes for roasting and agglomerating finely divided ores, is given by Mr. W. W. Norton in the August *Bulletin* of the A. I. M. E. Both systems of sinter-roasting are installed and in use at the Murray plant of the A. S. & R. Co., of which the author is superintendent. Five points of comparison are considered: cost of installation, cost of roasting, adaptability to wide range of materials, metal losses and physical condition of product. The author finds advantage in favor of the Dwight-Lloyd system on the first and third counts, in favor of the Huntington-Heberlein on the second and fifth, and is doubtful regarding the fourth. He gives results of furnace campaigns that show no advantage to reside in the physical condition of the Dwight-Lloyd product, either as to efficiency in reduction of the charge or speed of smelting. On the other hand he finds the Dwight-Lloyd excellently adapted to flexibility in the charge. No overwhelming advantage is found for either system.

Recovery of Zinc and Antimony in Lead Refining.—In the Parkes process for recovering the precious metals from base bullion, zinc is added to the molten lead in order to form an alloy with gold, silver and copper, which is removed by skimming. Antimony, if present, is not removed, and some of the zinc also remains. In order to remove these latter, air is blown through the molten mass, whereupon zinc and antimony oxidize, rise to the surface and are skimmed.

It has been found, also that the recovery of zinc and antimony from the desilverized bullion can be better accomplished in two stages. Zinc oxidizes first, and can thus be concentrated in a first skimming. The temperature is then raised, air is again blown through the bath and a second skimming removed which consists mainly of antimony.

At the Salt Lake meeting of the A. I. M. E., Mr. Richard D. Divine described a process for the treatment of this zinc-lead-antimony skimming, consisting in mixing it with sodium carbonate and pulverized oil coke, and heating in a reverberatory furnace on a bath of lead. Antimony and lead in the skimming are reduced and go into the lead bath, while zinc is volatilized as oxide.

The author suggests the possibility of applying the zinc-lead-antimony separation with sodium carbonate and coke, to complex zinc-lead ores after they have been roasted, and states that small-scale experiments

Gold and Silver

Ore Treatment at the Chaffer's Mill, Kalgoorlie.—A mill system said to represent the last word in the treatment of the ore at the southwest of the Golden Mile, Kalgoorlie, Western Australia, is described in the Aug. 5 issue of the *Australian Mining and Engineering Review*, by J. D. CONNOR. The ore is a hard, tough silica and softer quartz dolerite, containing precious metal irregularly disseminated in the free state, as telluride and locked in pyrite. The treatment method comprises dry crushing in Krupp ball mills to 100-mesh, followed by roasting in Edwards furnaces. The roasted ore is mixed with cyanide solution and ground in pans to a slime fine enough to pass 200-mesh. Amalgamation will be introduced at this point to catch any coarse gold. The slime will be thickened and agitated and filtered in a Ridgway vacuum filter. Precipitation will be by zinc shavings. Dry crushing is recognized as a dirty process, and provision is made against excessive dust by means of fans drawing dust from the ball mills and discharging it into a settling chamber.

Concentration

The development of the round table at Great Falls, Mont., presents an interesting example of the survival of one of the oldest forms of concentrating devices. The paper on this subject read at the Salt Lake meeting of the A. I. M. E. by Mr. ARTHUR CROWFOOT gives the history of the round table and its development from the stationary Cornish buddle. Many experimental data also are given, showing the reasons for adopting this type of machine in an important position in the flow-sheet of a modern copper concentrating mill. The paper contains extensive experimental data on wood, linoleum, cement and canvas surfaces, and conical and conoidal decks. The author is of the opinion that the round table will continue to maintain its supremacy over other types of machines for the concentration of minus 0.07-mm. slime from the ores of the Butte district as long as wet mechanical concentration is the most satisfactory method of recovering the valuable minerals from that class of material.

Smelter Fume Recovery

Electrical fume precipitation by the Cottrell process has been adopted at the Garfield smelter for the treatment of gases from the converters. The principal object is the recovery of lead fume. As described by Mr. W. H. HOWARD in the August *Bulletin* of the A. I. M. E., the process was adopted after experimenting with bag-house recovery as well as with the electrical process. Bags lasted only a few hours, due to the presence of an excess of unneutralized acid in the gases. One of the important developments of the experimental work on electrical precipitation was the adoption of iron pipes with axial wire electrodes in place of the regulation plates and pubescent electrodes which were first used at Coram, Cal. Another important development was the discovery that fractional precipitation of the constituents of the gas could be accomplished by successive treatments at different temperatures, the solid matter being precipitated at higher temperatures in one set of tubes and the acid, water and additional solids at a lower temperature in another set.

In Fig. 2 is shown a cross-section of the precipitating plant for converter fume. The converter gases will first pass through a 1000-ft. steel flue of 210 sq. ft. cross-sectional area, in which the cuprous material will be collected and the gases cooled. The precipitator consists of seven units containing 360 5-in. pipes, 10 ft. long, per unit. The gas velocity through

the pipes will range from 9.6 to 12 ft. per second, according to the number of units in operation and the volume of gas delivered. Gases from the converter flue will enter chambers below the pipes, pass through them to the upper chambers and thence to the flue leading to the stack.

The electrical apparatus comprises seven complete motor-generator-rectifier sets and transformers.

A set consists of a 30-hp., 250-volt, direct-current

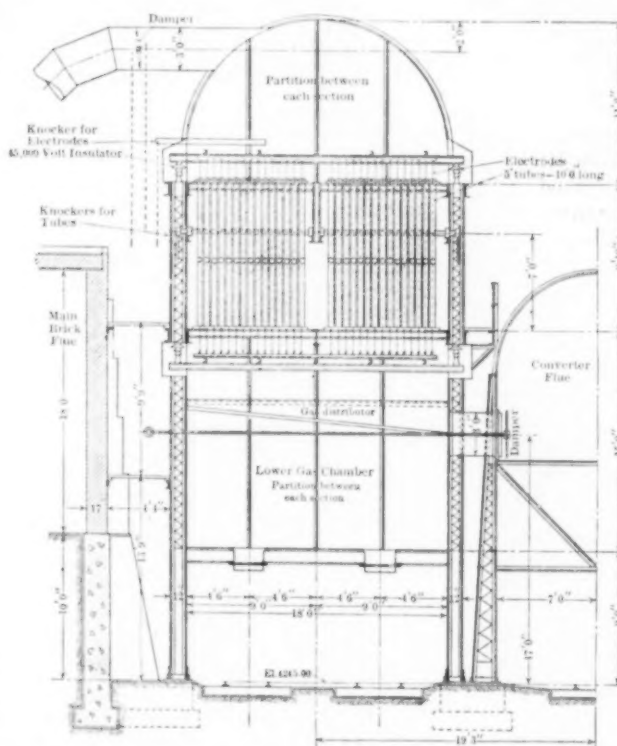


FIG. 2—CROSS-SECTION OF 360-TUBE UNIT FOR ELECTRICAL FUME PRECIPITATION

motor, direct connected to a 20-kw., 4-pole, 60-cycle, 220-volt single-phase alternating-current generator. The 220-volt current is stepped up to 20,000 to 30,000 volts by means of a 20-kw. transformer and then led back to the rectifier, which is on the same shaft with the motor generator. Here it is rectified before going to the treater. The voltage before going to the transformer may be regulated to any desired value by varying the field excitation with a rheostat located at the switchboard.

Crushing and Grinding

Laws of Kick and Rittinger.—In his presidential address before the Chemical, Metallurgical and Mining Society of South Africa, published in the August *Journal* of the society, Prof. G. H. STANLEY discusses the moot question as to the correctness of the laws of crushing promulgated by Kick and Rittinger. The author finds comparison of the two laws somewhat difficult "because the two laws do not deal with the same set of circumstances. Rittinger starts with a piece of ore of a certain size and compares the work done in breaking it into pieces of other sizes, while Kick, on the other hand, compares the work required to break, in a similar manner, pieces of ore of different sizes. In short, Rittinger refers to a constant total quantity, and Kick to a variable quantity." The author then proceeds from a mathematical discussion to deduce from Kick's law an expression of the same nature as Rittinger's, dealing with a constant total quantity. He finally arrives at this expression:

"The work required to reduce a given weight of rock from one size to another is proportional to the log of the initial diameter." Analyzing his calculations, the author states: "Practically it shows that provided the degree of reduction is small, experimental results might almost be in accordance with the Rittinger theory, and this has undoubtedly given much support in the past. As the size of the particles diminishes, however, the increase of surface is much more rapid than the work required to produce it, and, as stated by Richards, this was experimentally found to be the case by Von Reytt; and though the latter's object was apparently to prove the correctness of Rittinger's law, his results, on the contrary, tend to confirm the deductions I have made from Kick's."

Based on the author's statement of the law, he makes comparison of the efficiencies of breakers, stamps and tube-mills. He does "not consider the data available are sufficient for the close comparison of our crushing practice with theory, and, hence, for an exact calculation of efficiency, since we have not available, for instance, the real average size of the final product, or indeed any of them, but by making some assumptions some interesting results are obtained."

He then assumes that the average size of feed to the different machines and the average size of their products are as follows: Breaker, 6 in. and $1\frac{1}{2}$ in.; stamps, $1\frac{1}{2}$ in. and 0.1 in.; tube-mills, 0.15 in. and 0.004 in. These figures give respective ratios of $\frac{\text{original}}{\text{final}}$ diameter of rock of 4.0, 15.0, and 37.5, the logs. being 0.602, 1.176, and 1.574, respectively.

"The efficiency of the three types is expressed as actual tons per horse-power. The theoretical can only be determined from the results of measurements of the work required to break known cubes, and this is not available; it may, however, be taken as a function of a constant K . In the three cases cited the theoretical tons per horse-power will obviously be inversely proportional to the theoretical work required, i.e., as $\frac{1}{0.602} : \frac{1}{1.176} : \frac{1}{1.574}$ and is then a product of these fig-

ures, and K , i.e., $\frac{K}{0.602} \frac{K}{1.176} \frac{K}{1.574}$, in other words, the breaker should crush more tons per horse-power than the stamps, and the stamps more than tube-mills; but unless the practical figures obtained are in the same ratio the efficiencies will not be equal. Assuming that the tons per horse-power per day in the three cases are 12, 4.5 and 2, the efficiency will be proportional to 12×0.602 , 4.5×1.176 , and 2×1.574 or 7.22:5.29:3.15, i.e., efficiency is proportional to output per horse-power $\times \frac{\text{initial}}{\text{final}}$ diameter. Admittedly these figures can only

be rough approximations for want of accurate data, and the subject is important enough to justify an extended investigation with the object of obtaining reliable figures. I think the average diameter is probably less than I have assumed, the error being probably greater in the finest size, which would tend to show the tube-mill, in the calculation, in a less favorable light than it deserves. Nevertheless, assuming they are not very far from the truth, it indicates that the tube-mill is considerably more efficient than it is considered to be in some quarters.

Electric Precipitation of Fume.—Supplementing the paper of Mr. W. H. Howard on electrical precipitation at Garfield, read at the Salt Lake meeting of the A. I. M. E., Mr. EDGAR M. DUNN offers in the November

Bulletin of the Institute some data on similar work at Anaconda. A feature of the work at Anaconda is the experimentation with large-diameter pipe treaters. Those at Garfield are but 5 in. in diameter, but at Anaconda 3-ft. and even 4-ft. pipe treaters have been tested. In the treatment of mixed roaster and converter gases 3-ft. pipes have been used, 20 ft. long, and good clearance has been obtained with a velocity of 5 ft. The single axial discharge electrode is No. 29 nichrome wire, and the current from 150,000 to 160,000 volts. Blast furnace gases did not give so good clearance, probably due to poverty in moisture and SO_2 , as compared with roaster and converter gases. Tests will be made with 4-ft. treaters and voltage up to 220,000.

Fractional precipitation of gas constituents at successively lower temperatures has been used successfully in arsenic refining. Formerly it was the custom to volatilize arsenic from flue dust in two stages, the second being a refining stage to get rid of dust driven over in the first volatilization. It has been found that fractional precipitation, first at 310°C . and then at 90°C ., gives two products, the first consisting mainly of the dust and the second of white arsenic 99.7 per cent pure. This will eliminate the necessity of two furnace treatments as heretofore.

Tube-Mill End Liners.—The following description of a combination wood and steel end liner for tube-mills is given in the August *Journal* of the Chem. Met. & Min. Soc. of S. Africa, by Mr. J. F. PYLES. The author states that the idea of using wood and steel for tube-mill liners is not original, but believes that its

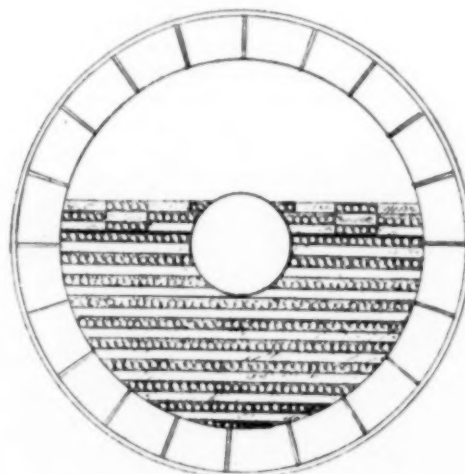


FIG. 1—TUBE MILL END LINER

practical utility has not been proved previously with regard to end liners. The adoption of this liner arose from the necessity of installing one that would not fall out, and from the importance of economizing steel.

As illustrated in Fig. 1, the liner is built around a sleeve $1\frac{1}{2}$ in. thick. The annular outer portion is built of 6-in. chert blocks, and the intervening space of alternate courses of scrap steel cut in 6-in. lengths, pine boards 1 in. thick and 6 in. wide, and 6-in. pegs.

"The procedure in building the liner is as follows: First place the casting or sleeve in position, then build in the outer layer of chert blocks, which have been previously shaped to fit the mill. These blocks are placed in the mill with Portland or magnesite cement and keyed in position. A layer of 6-in. pegs is then put in with their axes parallel to the sleeve and their sides touching each other, and embedded in mortar. Next a board 1 in. thick and 6 in. wide, touching the chert circle at each end, is laid on the pegs and tapped into place. Mortar is placed on this board and the next row

of pegs embedded in it, and so on until the liner is completed. The work of building this end liner will occupy one mason for half a day.

"The end has the following points to recommend it. It is inexpensive, both as to material and labor, and is quickly and easily installed. Owing to the wood absorbing the moisture from the cement, the end dries in a much shorter time than if only steel or chert were used. The swelling of the wood wedges the whole so tightly that all danger of the end, or any part of it, coming out is obviated.

"The life of the outlet end will be materially increased by staggering the wood and iron. This may be done by cutting the 1-in. board into pieces 6 in. square. Each row is then made by alternating 6 in. of steel with a 6-in. piece, and arranging the rows so that each piece rests on and is covered by steel. The pieces are placed with the grain of the wood parallel to the pegs."

Chemical Engineering

Cyanide from Coal Gas.—Supplementing an article in our December issue, page 696, on Coal Gas Residuals, by F. H. Wagner, we present an excerpt from a paper on The Recovery of Gas Works By-Products, by C. C. TUTWILER, published in the October *Journal* of the Franklin Institute. The portion selected has special reference to the making of cyanide from coal gas.

"Cyanogen occurs in coal gas as free cyanogen (CN)₂, and hydrocyanic acid (HCN), both of which are gases. It is formed by the combination of a small percentage of nitrogen contained in the coal, with the necessary amount of carbon. The amount occurring in the gas is dependent upon the temperature of distillation, high heats being conducive to a high cyanogen yield. A temperature of about 1735 deg. F. is said to be most favorable. The yield of hydrocyanic acid will then be between two and three ounces per thousand feet of gas. It is rare in this country that as much as three ounces are produced owing to the comparatively low heat carried. Several heats made in an American gas works showed something over two ounces; being higher at one station than at another in the same works, due presumably, to slightly different heats carried. At works where no attempt is made to remove the cyanogen from the gas, about 10 to 15 per cent is taken out in the ammonia scrubbers, and the rest more or less completely removed in the purifiers, occurring there as Prussian blue. Up to a few years ago the spent purifying material was the chief source of cyanides, but it was soon recognized that only a portion of the whole could be recovered in this way and attention was given to its recovery from the gas itself.

"Numerous processes have been devised for wet scrubbing, the earliest being the Knublauch system, which consists in bringing the gas, by means of a mechanical scrubber, into intimate contact with a solution containing an alkali and the salt of a heavy metal, preferably iron. In this way soluble ferro cyanides are formed and recovered from the wash liquor by evaporation and crystallization. There were several defects in the Knublauch system and at present it has given way to other systems which are more efficient and more easily controlled. All of these, however, except perhaps the process exploited by the British Cyanide Company are based upon the Knublauch principle. A brief outline of the most important systems in use to-day is as follows:

"**Feld Process.**—In the Feld system, the cyanide washer is placed immediately after the ammonia scrubber, operating on gas freed from ammonia. The washer employed is usually of the standard rotary or bubbling type. Solutions of lime and ferrous sulphate are used

as the scrubbing material, being introduced separately and continuously into the washer. The product obtained is a solution of calcium ferrocyanide, from which the pure salt can be crystallized.

"**Stavorinus Process.**—In the Stavorinus process the washer is placed immediately after the tar extractor and operates therefore on gas containing ammonia. The scrubbing material employed is a solution of potassium carbonate, and iron carbonate made from ferrous sulphate in suspension. The product obtained is a soluble alkaline ferro cyanide. Although the system is arranged for a continuous flow, the process is really intermittent. Two or three times a day a quantity of saturated liquor is drawn from the last bay of the scrubber and fresh liquor poured in. Since a large amount of ammonia is dissolved with the soluble cyanide, it must be recovered by boiling off in some form of concentrator. The residual sludge is then pumped into a filter, where it is converted into a clear solution and a cake, the solution consisting of potassium ferrocyanide, potassium sulphide and potash. This liquor is evaporated until it throws down the salt.

"**British Cyanide Process.**—In this process the gas is treated, immediately after the tar extractor, as in the Stavorinus process. A mechanical scrubber is employed having nine bays. Over eight of these bays is fixed a conical cup for holding the sulphur. Ammoniacal liquor is pumped into the washer at the outlet end, and granular sulphur is introduced intermittently into the eight bays. Ammonium sulphocyanide is formed and is disposed of as such.

"**Bueb Process.**—In the Bueb process, the cyanide washer is placed after the tar extractor. This process also operates on gas containing ammonia. A ferrous sulphate solution is employed as the scrubbing material. The product produced is a mixture of insoluble cyanides, which is sold in its crude state."

Notes on Chemistry and Metallurgy in Great Britain

(From Our Special Correspondent)

The Metallography of German Silver

In a paper communicated to the Chemical Society Mr. Frank Charles Thompson described a research of considerable interest carried out for the most part on actual commercial specimens of german silver subjected to ordinary works treatment and yielding results typical of the industrial alloys. The author remarked that almost the whole of the more directly industrially important knowledge of the copper-zinc-nickel alloys was contained in a paper by Hudson (J. Inst. Metals, 1913; i; 101), who, starting with the cast-steel metal traced its structural alterations on rolling and annealing; but only examined metal of one composition. Since these alloys consist entirely of Tafel's *alpha* solution (*Metalurgie*, 1908; Vol. V., page 419) they are metallographically strictly comparable with the *alpha* brasses. Further valuable information in M. Charpy's classical paper "Contributions a l'etude des Alliages" (Paris, 1901). Our present knowledge of the micrograph of the german silver alloys might be briefly summarized as follows: The commercial alloys consist entirely of the *alpha* solid solution, since the appearance of the *beta* phase is accompanied by a brittleness that renders them incapable of receiving the work to which they must be subjected. In the cast state the structure consists of cored crystals, which in these nickeliferous alloys are remarkably persistent under both mechanical and thermal treatment. Annealing at a proper temperature will in time remove this coring, giving place

to a structure consisting of entirely allotrimorphic crystals in which, however, unless the annealing has been very prolonged, traces of the cast structure may still be recognized. Like all *alpha* solutions these alloys are rolled cold, which treatment produces, if carried far, an indefinite linearity in the direction of greatest extension. The cord structure often persists after repeated rolling and annealing. When the cold-worked metal is annealed above a certain (minimum) temperature a recrystallization is effected, the degree of coarseness of which is increased as the annealing temperature is raised and as the time is prolonged.

In dealing with the effects of deoxidants the author stated that in the photomicrographs of the aluminium alloy an incomplete network, faintly to be seen, might afford an explanation of the idea held by certain makers of german silver that the presence of even small amounts of aluminium is detrimental to the properties of the metal. He, however, found that the refining action of 0.25 per cent of manganese or 0.5 per cent of aluminium was remarkable, and was the more curious because, at any rate in the case of manganese, the whole amount added had passed into the slag, hardly a trace remaining in the alloy. The finer structure of the deoxidized alloys imparted to them a tensile strength higher than that of the untreated metal; and in view of the fact that no chemical difference existed between the treated and the untreated specimens, no explanation appeared to meet the case so well as that of the amorphous cement theory of the intercrystalline boundaries.

The author also drew attention to the following analogies between german silver and steel. In practice the annealing temperature-range from 900 deg. to 700 deg. is the same for each; and the temperature falls as the percentage of nickel increases in the non-ferrous alloys and as the carbon increases in the steel. In each case overheating will cause a reintroduction of the cast structure with an accompanying loss of ductility. The mechanical properties of german silver are not dissimilar from those of a normal mild steel. In each case, increased nickel content means a diminution in the size of the grain. The mechanism of the recrystallization after cold work appears to follow the same course for both metals. As shown by the austenitic steels the original cast structure of each is the same; and there is reason to believe that the peculiar persistence of the cored structure in german silver has a counterpart in the ferrous metals. The author's conclusions are: That the oxygen in german silver is probably present as finely disseminated oxide of zinc; that deoxidants have a marked influence in giving a finer crystalline structure accompanied by better mechanical properties; that a curious reproduction of the "as cast" structure has been found in burnt metal; that lead and tin both cause separation of distinct components, probably lead and a compound of copper and tin respectively; and, finally, that marked analogies exist between the metallography of german silver and steel, and between their mechanical and annealing properties.

A New Gyroscopic Compass

Mr. E. Kilburn Scott and Capt. V. H. Rozie have devised a new form of gyroscopic compass which they have named the "Sea Star Type," and which was described and compared with the Anschütz and the Sperry instruments in a paper read before the Institute of Marine Engineers by Mr. Kilburn Scott. The author remarked that the Anschütz type of compass was of pendular construction and thus free to swing by the action of gravity. The Sperry gyroscope had a wire suspension, and was fitted with automatic "follow up"

mechanism to prevent twisting of the wire by the movement of the wheel and to overcome friction about the vertical axis instead of this being performed by the gyro-wheel. The motor of the "following" mechanism also drove the compass card and transmitting gear, and so left but little work to be done by the wheel. It was an essential feature. The source of errors affecting instruments of these types is traceable to their being pendular and dependent on the force of gravity for their effectiveness.

The compass designed by Captain Rozie and himself did not depend on gravity for the magnitude of its righting momentum which was determined by the deflecting momentum to be counteracted; and this was effected automatically and forcibly. The gyro-wheel is not liable to ballistic disturbance in consequence of its being mounted with the horizontal axis non-pendular. They had in view the elimination of correction tables and mechanical correction, and also the production of a small, cheap compass which could be used on merchant ships and aircraft. The increased sensitiveness requisite in a small instrument had been attained by rotating the gyro-wheel in a direction opposite to that of the earth's axial rotation, so that the direction of rotation of the wheel was dextrorotary when regarded from the northern side, with the consequence that the wheel was permanently in a state of unstable equilibrium. Then as soon as the slightest deflection occurred the tendency to increase deflection became very strong and caused the instant starting of the motor to remedy the deviation. Consequently the sensitiveness in meridian was very great, and the kinetic energy of the gyro-wheel became of less importance than it was in other instruments. In the Anschütz and the Sperry compasses the direction of rotation of the wheel coincides with that of the earth's rotation.

The Tensile Properties of Copper at High Temperatures

Dr. G. D. Bengough and Mr. D. Hanson gave the results of their investigations of the effects of high temperatures on copper in various atmospheres. They found that the nature of the atmosphere was an important factor; and that an oxidizing atmosphere at high temperatures gave a high degree of ductility. In a neutral atmosphere, at all temperatures from 20 deg. C. up to 1000 deg. C. pure unannealed rolled copper retains all its superior strength as compared with annealed copper. With pure annealed copper fracture occurs through the crystals at all temperatures below about 700 deg. C., while at all higher temperatures above 750 deg. C. it occurs between the crystals; and between 700 deg. and 750 deg. it may occur in either way but has a preference for the intercrystalline path. Confirmation was obtained of the existence of a range of low ductility at temperatures about 250 deg. to 450 deg. C.

Small quantities of oxygen or of arsenic in copper have the effect of decreasing the tensile strength at high temperatures, but increased ductility has also been observed. In an atmosphere of hydrogen, at temperatures above about 720 deg. C., the test bars gave a tensile strength about half a ton per square inch lower than those tested in a neutral or an oxidizing atmosphere. The authors considered that this is probably due to reduction of copper oxide, which action might weaken the bars and ultimately cause cracking. As a whole, the results of the tensile tests are consistent with the theory of the crystals of copper being enveloped in a cement which at low temperatures is stronger than the crystals themselves but weaker at high temperatures; yet there are two points of interest which must at present be excepted from this explanation.

Heating Alloys in Vacuo

A paper by Mr. W. E. Thorneycroft and Professor T. Turner gave some very interesting results of experiments carried out with the object of determining the effect of percentage of copper on the rate of the removal of zinc from copper-zinc alloys when suitably heated in a vacuum.

The authors arrived at the following conclusions:

Alloys containing upwards of 40 per cent. of copper can be separated quantitatively into their constituent metals, but when the copper content is less than 40 per cent. some of the copper is volatilized with the zinc. Copper-zinc alloys which contain a high percentage of zinc are slightly more volatile than pure zinc, and it is probable that one particular alloy will be found to have the lowest temperature of volatilization out of the whole series of alloys. Alloys containing a high percentage of copper require for complete separation of the zinc a degree of heat decidedly greater than that requisite for the volatilization of the separated zinc.

Electrolytic Iron

Among the papers presented for reading at the abandoned Paris meeting of the Iron and Steel Institute was one by Prof. L. Guillet dealing with the commercial production of electrolytic iron. The author stated that the Le Fer Company, of Grenoble, has taken out patents since 1910 for the electrolytic manufacture of iron. The method consists essentially in the use of a revolving cathode in a neutral solution of iron salts, the neutrality of which is maintained by constant circulation about the anode. Periodic additions of oxide of iron effect depolarization by partially removing hydrogen from the surface of the cathode, and permit the use of a current having a density as high as 1,000 amp. per square meter. From a solution made with ordinary pig iron a product can be obtained of a very high degree of purity. After removing occluded gases by annealing the metal contains an average of only 0.004 per cent. of carbon, 0.007 per cent. of silicon, 0.006 per cent. of sulphur and 0.008 per cent. of phosphorus. When taken from the bath the metal is hard, very brittle and contains occluded gases, notably hydrogen. Sir Robert Hadfield obtained 28.8 cc. of gases from a sample of the iron weighing 34 grammes, having a volume of 4.33 cc., by heating it in a vacuum for four hours at 800 deg. C. to 1,100 deg. C. and for two hours more at nearly 1,400 deg. C. The relative volumes of the gases were, hydrogen 18.8, carbon monoxide 7.4, carbon dioxide 0.2 and oxygen 2.2. The Brinell hardness of the crude iron is 193 with a ball of 10 mm. in diameter and a load of 3,000 kg., and the micrographic structure is composed of exceedingly numerous fine needles, closely resembling martensite. Annealing in magnesia for two hours at 900 deg. C. reduces the Brinell hardness to 90 and imparts a perfectly normal micrographic structure.

Tensile tests on tubes gave a breaking strength of 30.9 to 32.8 kg. per square millimeter (about 20 tons per square inch), with an elongation of 40.2 to 42.1 per cent. in the direction of the axes. Annealed tubes withstand compression tests producing more than ordinary deformation without exhibiting any sign of fracture. One tube 100 mm. in diameter and 0.75 mm. thick when subjected to a pressure of 1,200 lb. per square inch showed a deformation as regular as if it had been squeezed in a press. Another portion of the same tube was exposed for 2½ months to a temperature of 120 deg. in a steam boiler and then withstood a pressure of 1,200 lb. per square inch without any sign of fracture being perceptible.

Tubes are being manufactured by Messrs. Bouchayer

and Viallet, whose plant is equal to an output of 100 lengths per day. The tubes are uniformly 4 metres long, and vary in diameter from 100 mm. to 200 mm. and in thickness from 1 mm. to 6 mm., and the great regularity in the thickness obtained contrasts strongly with the inequalities prevailing in the tubes made in the ordinary way, particularly when the thickness is less than 6 mm. The manufacture of sheets is still in the experimental stage, but hopes are entertained of their direct production without rolling. The quality of the iron is first rate, and as it can be worked with remarkable facility, it is especially suitable for stamping both as black annealed plate and as tinplate. The great purity of the sheets endows them with a particular value in the construction of electrical machinery by reason of the increased efficiency to be secured and the reduction in the weight of the material to be effected.

For the manufacture of steel the electrolytic iron appears likely to compete quite successfully with the best Swedish iron. Its quality is very regular, and its brittleness enables it to be broken into small pieces of any required size, and consequently it lends itself to a more uniform cementation than does ordinary material. Tool steel and special steel giving results at least equal to those obtained with similar steels made from Swedish iron have already been produced at several steel works. Working with a current density of 1,000 amp. per square meter a yield of two tons of very pure iron per kilowatt-year is obtained; but when the density is reduced to 500 amp. per square meter the output per kilowatt-year is nearly doubled, and on the latter basis the total cost of production, making ample allowance for waste of pig iron, depreciation, etc., is estimated at from £6 to £7 12s. per ton, according to local conditions.

Electrolytic Iron

It appears that the process for the production of electrolytic iron in tubes and sheets described in the paper by Prof. L. Guillet had, according to a statement in the *Times*, already been worked out in England by Mr. S. Cowper-Coles, and that works are to be erected in the Midlands for the commercial manufacture of sheets, tubes, etc. In 1908 Mr. Cowper-Coles read a paper before the Iron and Steel Institute in which he gave details of the electrolytic production of finished iron tubes and sheets in one operation. In his process he employed a mandrel revolving at a critical speed in order to give sufficient "skin friction" between the electrolyte and the deposited metal to obtain a close homogeneous deposit and to permit the use of a high-current density, whilst the solution was kept neutral by circulation over the anode. In the following year a license was granted to Mr. Boucher to work the process in France and Switzerland, and a small trial plant was put down in Switzerland with which a number of tubes was produced. The Compagnie Le Fer was subsequently formed to acquire this license. (The Cowper-Coles process was described in detail in a paper by Messrs. W. Palmaer and J. A. Brinell in our issue of April, 1913, Vol. 11, page 197.)

The Influence of Coke on Corrosion

The paper by Mr. Arnold Philip, an abstract of which was given in last month's letter (page 724), which expressed views and quoted results quite opposite to those given by Dr. Bengough and Mr. Jones in their report to the corrosion committee of the Institute of Metals has called forth an energetic reply from those gentlemen. They expressed surprise that the results of Mr. Philip's researches should have been so completely contrary to those obtained in their own in-

vestigations, and decline to admit that the contact of coke with condenser tubes in seawater induces electrochemical action. They point out that Mr. Philip carried out his experiments under conditions essentially different from their own tests; and that, consequently they propose to undertake further investigations, as at present there is uncertainty as to how the variation of conditions affects the results. In reply to Mr. Philip's definite assertion that in all his experiments, without exception, he found that the presence of coke caused accelerated corrosion, and also apparently dezincification in two days in seawater at ordinary temperatures with accelerated action at higher temperatures. They state that in no case did they observe dezincification in less than seven days at 50 deg. C., or about seven months at ordinary temperatures, whether coke were present or not.

Water Softening

The results of a series of experiments are recorded by Mr. W. Buscoe Baron in the Manchester paper *Vulcan*. In summarizing the results he considers the importance of bringing water to which softening chemicals are added, intimately in contact with crystalline calcium carbonate to be the means by which the lowest results are obtained. He points out that every effort should be made to soften the water without involving excess of alkali. The experiments dealt with lime permanent hardness.

Market Prices

October, 1914.

	£	s	d
Aluminum ingots, ton lots.....	88.	0.	0
Alum, lump, loose per ton.....	£5.5.0	to	5.10.0
Antimony, black sulphide powder, ton.....	23.	0.	0
Borax, British crystal, cwt.....	18/6	to	19. 6
Copper sulphate, ton.....	22.	0.	0
Caustic soda, 70 per cent, per ton.....	9/9	to	10. 3
Copper ore, 10 to 25 per cent, unit.....	not fixed		
Ebonite rod, lb.....	3.	0.	0
Hydrochloric acid, cwt.....	nominal		
India rubber, Para, fine, lb.....	2.	7 1/2	
Mica, in original cases, medium.....	3/—	to	5. 0
Petroleum, Russian spot, gal.....	not fixed		
Quicksilver, Spanish, bottle.....	10.	5.	0
Sal-ammoniac, cwt.....	not fixed		
Sulphate of ammonia, ton.....	10.10.	0	
Shellac, per cwt.....	3.	0.	0

The Metal Exchange remains closed; prices are therefore approximate.

Copper—Best selected copper was fixed at £56.5 to £56.15. on the 6th, £55.10. to £56 on the 9th, and closed at £54.5. to £55. Copper has been obtainable at £52.10.

Tin opened at £134 to £136, and was harder in the third week. From the 16th to the end of the month it was £133.

Haematite opened at 66/-. On the 16th was 66/- at Glasgow, and the same on the 23rd, but had fallen to 62/- by the 30th.

Scotch Pig—Closes at 55/4 1/2 d.

Cleveland—Opened at 50/11; selling at 50/0 1/2 on the 9th, subsequently went lower. Rose a little on the 19th to 49/6 1/2, afterwards becoming quieter and closing at 49/-.

Lead—Opened at £19.15. and closed at £18.10.

American Peat Society.—The 1915 meeting of the American Peat Society will be held in Detroit, Mich. Mr. Carl Kleinstück, of Kalamazoo, Mich., is the president, and Mr. Julius Bordollo, Kingsbridge, N. Y., the secretary of the American Peat Society.

Thermit in a Municipal Repair Plant.—The repair shop connected with the Bureau of Water, Department of Public Works, Philadelphia, Pa., has adopted thermit for heavy repairs. Some repairs carried out in this shop are the subject of an interesting illustrated article in issue 3, 1914, of *Reactions*, published by the Goldschmidt Thermit Company, of New York.

Recent Chemical and Metallurgical Patents

Iron and Steel

Briquetting Iron Ores.—The use of tar, from which water and the light and middle oils have been removed, is suggested as a suitable binder for iron ores, in a patent granted to Mr. GEORG CRUSIUS, of Gross-Ilsede, Germany. The inventor claims that the use of ordinary soft tar is not advantageous on account of its content of light oils that distill out of the briquets when subjected to the heat of the furnace; but the use of specially prepared tar is without these objections and gives good results. (1,116,024, Nov. 3, 1914.)

Cooling Open-Hearth Furnace-Ports.—A mechanism for cooling the arches and maintaining the gas ports of metallurgical furnaces, patented by Mr. FRANK E. PARKS, of Pueblo, Colo., consists in a port structure comprising a water-cooled frame of separate hollow cooling elements. Each cooling element is provided with several conduits for supplying a cooling fluid, and provision is made for maintaining a circulation through one or more conduits while others may be inactive. (1,113,245, Oct. 13, 1914.)

Copper, Lead and Zinc

Extracting Copper from Carbonate and Oxide Ores.—In several patents recently granted to HENRY R. ELLIS, of Salt Lake City, Utah, he amplifies a process of extracting copper from carbonate and oxide ores by solution with carbonate or bicarbonate of sodium or potassium, and electrolysis of the solution. The present invention specifically makes use of a mercury cathode and insoluble anode. It is claimed that when using a mercury cathode a current density may be used of many times that permissible when copper is the cathode. The ore is crushed in solution to a thin slime and conveyed to the electrolytic vat where the copper is precipitated. The slime is kept in suspension by agitation. One method of using the mercury cathode is shown in Fig. 1, in which the vat

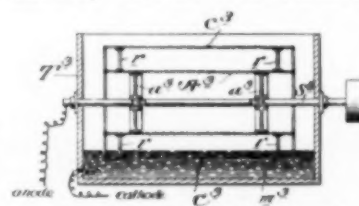


FIG. 1—ELECTROLYSIS OF ALKALINE COPPER SOLUTION

by non-conducting radial supports *r*. The cathode revolves in a bath of mercury *m*. (1,115,521-2-3, Nov. 3, 1914.)

Heating Leaching Solutions.—A method of heating copper leaching solutions by the heat absorbed from water used in ore-coolers, is patented by FREDERICK LAIST, of Anaconda, Mont. The idea is illustrated as applicable to a form of ore-cooler patented by Mr. Laist and reviewed in this journal, May, 1914, page 352. In that cooler the hot ore is cooled by means of water pipes extending the length of a drum, entering at the point of ore discharge. The hot water issuing from these pipes at the end of the drum at which hot ore is charged, is then led to a tubular heater where its heat is transferred to a leaching solution. The latter flows through the tubes of the heater, which are surrounded by the hot water from the cooler. (1,115,689, Nov. 3, 1914.)

Furnace for Producing Lead Pigments.—In the manufacture of lead pigments, for example minium, or red lead, accurate control of conditions in all parts

of the furnace is an essential. To secure this control of Mr. CLIFFORD D. HOLLEY, of Detroit, Mich., has designed and patented a reverberatory furnace with a pair of grates at opposite ends of the hearth, and a number of waste-gas exits at different points above the hearth, so that the course of the flame and fire gases over the hearth can be changed at will. The firing may be by any of the usual means—coal, coke, gas or oil. The furnace has charging and discharging doors at back and front, respectively. (1,116,703, Nov. 10, 1914.)

Retort Discharging Machine.—In Fig. 2 is shown a side elevation of a machine patented by JOHN J. SIMMONDS, of Iola, Kans., adapted to the operation of discharging zinc retorts after the distillation process is

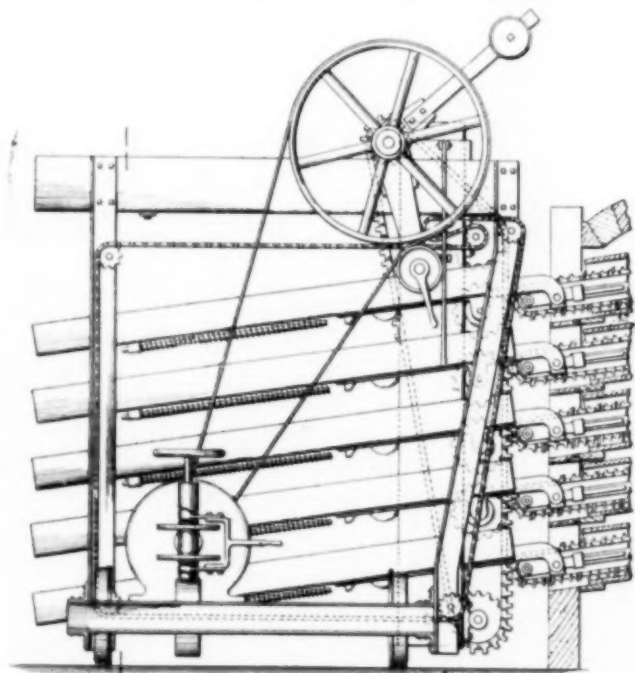


FIG. 2—RETORT DISCHARGING MACHINE

complete. It comprises a number of mechanically driven elements arranged to enter the retorts of a furnace and clean them out. The elements consist of endless chains moving over sprocket wheels and carrying scrapers which progressively remove the residue from the retorts simultaneously with the advance of the elements. The machine is mounted on a car movable along a track in front of the furnaces. (1,110,081, Sept. 8, 1914.)

Recovery of Zinc from Refuse.—The prevention of metal loss in the zinc-bearing refuse of brass foundries and rolling mills is the purpose of a process patented by Mr. RALPH R. PARISH, of Waterbury, Conn. The material is gradually introduced into a tank containing a 1 per cent to 5 per cent solution of sulphuric acid. The mixture is continuously agitated with compressed air, and when the density of the zinc solution has reached from 30° to 45° Baume the remaining acid is neutralized by the addition of an excess of zinc-oxide refuse. This precipitates iron, and agitation is continued until all iron has been removed from solution. If manganese is present ozonated compressed air is used to convert that metal into an insoluble oxide. Freed from iron and manganese, the zinc solution is either decanted or filtered. It still contains such impurities as cadmium and copper, but these are removed by precipitation with zinc in the form of dust or shavings. The resulting pure solution of zinc sul-

phate is then evaporated to crystallization or electrolyzed to produce pure zinc metal. (1,104,922, July 28, 1914.)

Apparatus for Isherwood Zinc Process.—In Fig. 5 is shown an extracting and filtering apparatus patented by Mr. PERCY C. C. ISHERWOOD, of Bushey Heath, England, for the treatment of refractory zinc ores. It consists of a longitudinal casing mounted on rollers and adapted to be revolved. A central partition ex-

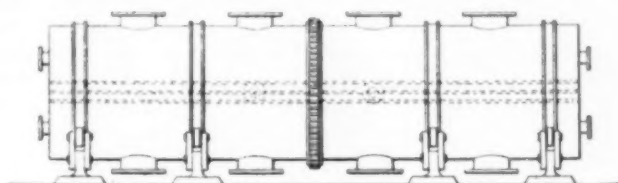


FIG. 3—ISHERWOOD ZINC DIGESTER AND FILTER

tends the length of the casing, dividing it into two separate parts, each with manholes as shown. On each side of the central partition is a filter with suitable outlets for discharging filtered solution. The charge of ore and solvent is introduced into one compartment of the casing, and steam is forced in under pressure, thereby heating the solution to a high temperature. The casing is then revolved until this compartment is lowermost, and may be reciprocally moved in that position to aid in solution of the metal. In the meantime the upper compartment is being charged. When the treatment of the first charge is complete the casing is rotated 180 degrees, whereupon the coarse particles in the first charge fall on the filter and under the finer particles. Filtration of the solution can then proceed under the internal pressure generated by the steam. After filtration the casing is again rotated and the tailing discharged through the manholes. Both compartments are alternately in use in different stages of a complete cycle of treatment, effecting economy in time and space. The process has been tried in an experimental plant at Perth Amboy, N. J., and it is stated that experiments with it are to be continued on a larger scale at Keokuk. (1,110,790, Sept. 15, 1914.)

Electric Zinc Furnace with Integral Condenser.—A resistance furnace for the reduction of zinc oxide obtained as a product of igneous concentration is shown in section in Fig. 4, being the invention of Mr. CHARLES V. THIERRY, of Paris, France. The heat is derived

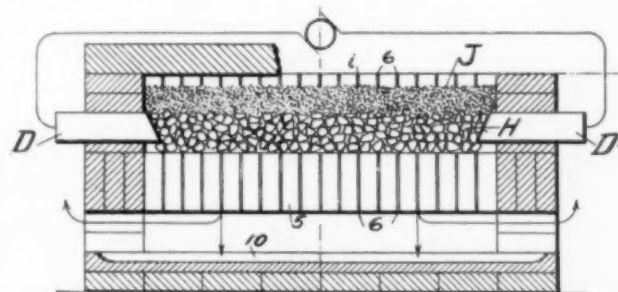


FIG. 4—ELECTRIC ZINC FURNACE WITH INTEGRAL CONDENSER

from the passage of a current through a resistor H of broken carbon resting on the hearth of the furnace between carbon terminals D, D'. The charge J rests on the resistor. The walls of the furnace adjacent to the longitudinal sides of the resistor, and the sole or hearth of the reaction chamber, either or both, form the condenser. Slots or crevices 6 in the walls and hearth provide for the evacuation of the gases and

metal fumes, the latter being condensed and collected in an underlying receptacle 10.

In the beginning of an operation the gases evolved escape through the numerous fissures and, being under some pressure, will prevent the entrance of air. They will also assist in progressively heating the sidewalls of the fissures. The inner faces of the walls will become heated to the temperature of the resistor, and will be heated by conduction in a progressively diminishing ratio toward their outer surfaces. The inventor is of the opinion that these conditions are favorable to the condensation of zinc. (1,110,359, Sept. 15, 1914.)

Sintering Zinc Retort-Residues.—The preparation of zinc retort-residues for the recovery of their precious metal contents by smelting in the blast furnace is accomplished by burning them in heaps or piles, utilizing their contained coal as fuel. As outlined in the patent on the process granted to Mr. ARCHIBALD JONES, of Bartlesville, Okla., the beneficial effect of this treatment is three-fold: the carbon is eliminated, thereby reducing the weight and consequent cost of freight; the zinc content is greatly reduced, the sublimed zinc being condensed in the outer layer of the pile and subsequently recovered for retort reduction, and the material is sintered into a mass which, on being broken to suitable size, makes a good blast-furnace feed.

The residues are taken from the retorts and deposited on the ground over a system of trenches or flues made of fire-clay tile. One end of the main flue is connected with a source of air-blast of about 1 ounce pressure per foot of residue in the pile. Fuel may be used at points in the flue system in order to initiate the ignition, but ordinarily the 30 to 40 per cent of fuel in the residue is sufficient for combustion. As combustion is propagated throughout the mass, zinc is volatilized and condensed in a surface crust, which is removed and resmelted. The finished sinter is practically free from carbon and zinc, and can be smelted for recovery of other metals. (1,112,010, Sept. 29, 1914.)

Manufacture of Zinc Oxide.—In a patent granted to Mr. J. A. SINGMASTER and assigned to the New Jersey Zinc Co., the inventor discloses a scheme for producing zinc oxide in a continuous operation. The process is claimed as an improvement on the Wetherill process using stationary grates. According to the invention the charge of ore and fuel is placed on a moving car, forming a traveling grate which advances through the combustion zone where the reactions take place with uniform combustion and complete utilization of all the valuable elements of the charge. Fig. 5 gives

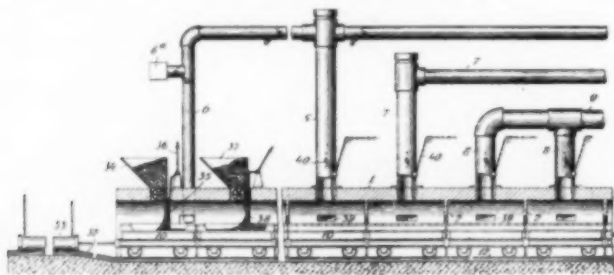


FIG. 5—CONTINUOUS PROCESS FOR MAKING ZINC OXIDE

an idea of the furnace with its several flues for handling the gases evolved at different stages of the process.

The tunnel is of masonry, about 150 ft. long and 7 ft. by 6 ft. internal cross-section. The interior is provided with a series of partitions 2, depending from the roof and serving as baffles to prevent movement

of gas between the combustion zone and the ends of the tunnel. From the pockets formed between these partitions leads an off-take for the gas or fume. These permit the separate disposal of the metallic and non-metallic fumes that come from a charge at different points in the tunnel. The first, as at 5, is for the non-metallic gases which may be used for fuel, being distillation products from the coal. The next, 7, is for the first metallic fume which may be of poor grade and not suitable to be mixed with the finest product of the furnace. The others, as at 8, are for the zinc oxide that is produced when the process is at its height, and are combined in a long flue 9, leading to the bags. Details of mechanical construction are given in the patent specifications. (1,112,853-54, Oct. 6, 1914.)

Tin

Detinning Process.—The removal of tin from tin-coated metal may be accomplished by treatment with a slime containing a solution of a tin salt and gray tin, according to claims in a patent granted to WALLACE SAVAGE, of Piedmont, Ala. He claims to have discovered that a coating of ordinary white tin may be changed to a dark, amorphous, nonadherent powder known as gray tin by the catalytic action of gray tin, and that the change takes place most satisfactorily when gray tin is employed in connection with a solution of a tin salt, preferably tin ammonium chloride, known as "pink salt." The reaction occurs at ordinary temperatures, but is preferably brought about below a temperature of 68 deg. F. The slime is produced by dissolving 10 lb. of tin ammonium chloride in 100 gal. of water and mixing with this solution about 2500 lb. of gray tin. On application of this mixture to tin-coated metal, the tin is separated as an amorphous powder. (1,113,491, Oct. 13, 1914.)

An improvement in detinning by means of chlorine, using a mixture of air and chlorine, is patented by GUSTAV VON DER LINDE, of St. Tönis, near Crefeld, Germany. It consists in producing a uniform mixture of air and chlorine of suitable concentration by means of diffusion, and then allowing this mixture to act

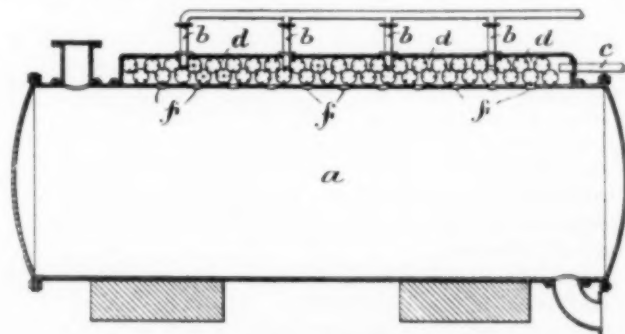


FIG. 6—APPARATUS FOR DETINNING

on the metal to be treated. The method of securing the uniform mixture is to pass chlorine into a chamber charged with distributing bodies filled with air, as for example Guttman's hollow balls. After the chlorine fills the chamber containing these bodies, air rapidly diffuses into the chlorine and forms a uniform mixture which is then distributed over the metal to be treated. By reduction of the pressure caused by the formation of tin chloride, air is again drawn through a seal into the distributing bodies so that the process of uniform dilution can be repeated. The process is performed in apparatus shown in Fig. 6, in which *a* is a receptacle charged with tin scrap, and which communicates with a chamber *d* through holes in the receptacle *a*. The chamber *d* is connected with chlorine supply pipes *b*

and a pipe *c* that leads to an acid seal. The chamber *d* is charged with hollow distributing bodies *f*. Chlorine is intermittently supplied to the chamber *d*, mixed with the air of the distributing bodies and finally admitted to the chamber *a*. When the pressure in the latter is reduced by the reaction, air is drawn into the chamber *d* through the pipe *c*, so that the distributing bodies again become filled with air. (1,116,176, Nov. 3, 1914.)

Rare Earths

Electrolytic Separation of Rare Earths.—In describing a method for fractionally electrolyzing solutions containing yttrium, erbium, thorium, cerium and zirconium, LOUIS M. DENNIS, of Ithaca, N. Y., states that heretofore experiments on such separation have failed due to the fact that the compounds formed by electrolysis have adhered to the electrode in such manner as to increase the internal resistance of the cell to a point where appreciable separation was impossible. He has discovered that if the surface of the cathode be kept free from adhering deposits, the elements referred to may be fractionally separated in the form of compounds, such as hydroxides. In the preferred form of apparatus he uses a glass cell with a mercury cathode and platinum anode. The following example of electrolysis is cited: 25 grams of the oxides of the yttrium group of rare earths may be dissolved in nitric acid and evaporated to dryness. The residue is taken up with 500 cc. of water and electrolyzed for 6 hours at 9 volts. At the end of that time a precipitate of hydroxide is formed which is removed by filtration. The solution is then again electrolyzed under the same conditions, when a further precipitate is formed and removed. The process may be repeated for the number of fractions desired. Examination of the two fractions shows that a rapid and quite complete separation of yttrium from erbium has been effected. (1,115,513, Nov. 3, 1914.)

Ore Cooler

Apparatus for cooling roasted ore is shown in Fig. 7, being the invention of ROBERT W. HANINGTON, of Denver, Colo. It consists essentially of two concentric cylinders mounted on a hollow shaft supported in an inclined position. The inner surface of the outer cylinder and the outer surface of the inner cylinder are provided with Z-shaped flights which serve to catch the ore fed into the space between the two cylinders and distribute it over their surfaces during the rotation of the machine. Water is distributed over the outer cylinder from a launder supported above the cooler, and is sprayed over the inner surface of the inner cylinder through perforations in the hollow shaft. During the rotation of the machine the ore passes from the feed to discharge end due to the inclination of the cylinders. (1,101,433, June 23, 1914.)

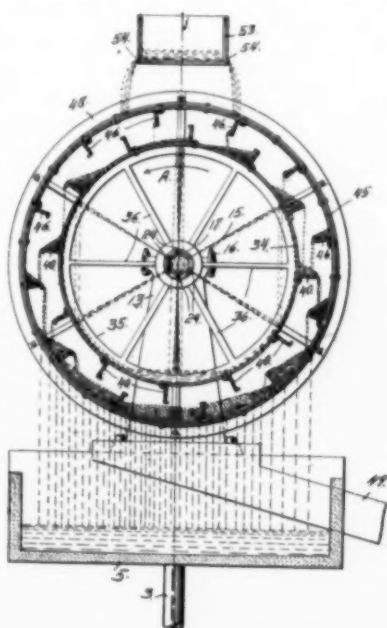


FIG. 7—ORE COOLER

Zirconia, a New Refractory

BY H. CONRAD MEYER

Among the numerous so-called rare elements, zirconium has, to within the last few years, ranked as technically unimportant. The development of the electric furnace, requiring for its construction bodies having an extraordinarily high degree of refractoriness, has probably been an important factor in calling the attention of the electrometallurgist to the possibilities of zirconia.

In the year 1788, the German mineralogist, M. H. Klaproth, while engaged in the analysis of the mineral zircon, discovered that apparently 68 per cent of the mineral consisted of a very inert substance differing in its properties from all other substances known at that time, and which he ultimately determined to be the oxide of a new element. Having been first recognized in the mineral zircon, the name zirconium was proposed and ultimately adopted.

The element zirconium in the free state occurs in three forms: amorphous, crystalline and graphitic. It has a density of 6.4 in the crystalline form, with a melting point of about 2350 deg. C. As the element has no important use in its uncombined state at the present time, we will not dwell further upon its properties. It is not as rare as commonly supposed, having been determined by careful calculation to constitute 0.03 per cent of the lithosphere,¹ about as plentiful as the element carbon.

Sources.—At the present time there are only two known minerals which occur in sufficient quantities to be considered as commercial sources of zirconium. The first of these is the natural oxide zirconia; the second, zircon or the silicate. As zirconium oxide is generally the starting point for all zirconium compounds, the natural oxide is thus more eminently fitted as a commercial source than zircon. As found in nature, natural zirconia carries about 84 per cent of the pure oxide, with about 8 per cent silica and 3 per cent iron oxide. There are several methods in vogue for the extraction of the pure oxide, the best known being that of fusing the natural substance with sodium carbonate or hydroxide, thus producing sodium zirconate, which on being leached is hydrolized, forming soluble sodium silicate and insoluble zirconium hydroxide. The precipitate after thorough washing, can be readily converted into soluble salts by treating with any of the strong mineral acids.

Refractory Properties of the Pure Oxide.—Refined zirconia is a pure white substance, having a density of about 5 and a melting point of 3000 deg. C., according to Weiss. The first important use found for the oxide was to replace the calcium oxide cylinders used in the Drummond or so-called lime light. The great objection to the calcium oxide was its rapid deterioration, owing to its absorption of moisture and carbon dioxide from the air. Besides giving a more intense illumination, zirconium oxide was absolutely unaffected by moisture or any of the atmospheric gases.

Later, in 1880, R. von Welsbach impregnated loosely woven cotton or linen fabric with zirconium nitrate, securing a skeleton of zirconium oxide by incineration. The form of the fabric, thus perfectly preserved, became highly incandescent when heated in the flame of an ordinary Bunsen burner. Subsequent experiments proved, however, that thorium gave the same results at a much lower temperature. Therefore, it has almost entirely replaced zirconium for this purpose. These experiments of von Welsbach mark the inception of the incandescent gas mantle industry.

¹Data of Geochemistry, F. W. Clarke, Bulletin 491, U. S. Geological Survey.

The next important application of the pure oxide occurred in 1897 in the Nernst light, developed through the behavior of certain refractory oxides, which, when heated to a high temperature, become excellent conductors of electricity and glow with an intense white light. This lamp consists essentially of a number of small rods or "glowers" composed of magnesia, zirconia and yttria. By a suitable heating device, the glower is raised to a temperature of 634 deg. C., at which point current begins to flow, raising the oxides to incandescence. As the quantity of zirconia used in the Nernst lamp is comparatively small, no great commercial application can be looked for in this quarter.

The remarkable heat-resisting qualities of zirconia at once commended it as a refractory of the first order. Its high melting point, low coefficient of expansion and low thermal conductivity, make it apparently the ideal lining for electric furnaces of the arc type. The pure oxide, owing to the comparatively high cost of extraction, is too costly a material for industrial uses on a large scale. Careful tests have shown, however, that natural zirconia is eminently fitted for such work and has only a slightly lower efficiency.

Very remarkable heat-resisting ware, such as crucibles, muffles, pyrometer tubes, combustion boats and resistance cores for electric furnaces, can be manufactured from pure zirconium oxide mixed with from 3

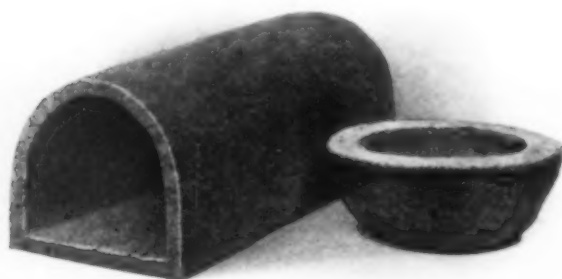


FIG. 1—ZIRCONIA MUFFLE AND ACID DISH

per cent to 10 per cent magnesia, using starch, phosphoric acid, glycerine or borates as binders. The ware is dried for several days at a low temperature and then fired in the electric furnace at a temperature ranging from 2000 deg. to 2300 deg. C. This ware is practically impervious to liquids, and is not affected by strong acids or alkali fusion mixtures.

Owing to the extremely low coefficient of expansion, zirconia ware can be subjected to very sudden changes of temperature, such as plunging a red hot crucible in water, without the slightest danger of fracture.

The fusing point of tungsten alloys and the boiling point of pure iron, according to recent investigations,² have been successfully determined in zirconia crucibles.

The cost of the pure oxide for the manufacture of such articles as the foregoing and other ware requiring a maximum resistance to heat and corrosive action, is at the present time not prohibitive, as it can be readily prepared from the natural zirconia by the method already briefly outlined. An iron-free oxide can also be prepared, according to a recent process, at a low cost.³ The pure oxide mixed with sufficient sodium silicate or phosphoric acid to form a plastic mass, affords a cement or lute capable of withstanding the severe temperatures of electric furnaces of either the resistance or arc type.

Refractory Properties of Natural Zirconia.—To compete with the various high-grade refractory bodies now

used industrially, zirconia must possess certain superior properties lacking in these cheaper refractories, such as a higher melting point or greater resistance to chemical agencies. In other words, the initial cost of a zirconia lining, which is rather high as compared with, for example, magnesite brick, is more than offset by its high melting point, (3200 deg. F. to 3600 deg. F.), high resistance to corrosive slags, metals or metallic oxides, low thermal conductivity and low coefficient of expansion. All of these superior factors indicate the life of a zirconia lining to be of very much greater duration than the best natural refractory lining now available.

Actual working tests made on a Martin-Siemens furnace in a steel works at Remscheid, Germany,⁴ using a zirconia-lined hearth, show that after four months of continuous operation at high temperatures, the hearth was still in good condition and would serve at least four months longer before renewal. Careful statistics compiled from these tests show a saving of 50 per cent in actual maintenance costs in favor of the zirconia lining over an ordinary refractory lining such as is generally used. No allowance was made for increased production and higher efficiency. Owing to the low thermal conductivity of zirconia (about one-half that of ordinary fire brick), it has been demonstrated in actual practice that a 2-in. lining is equivalent to 4 in. of chamotte.

The high resistance of this refractory to such metals and alloys as copper, steel, bronze and red brass, should commend its use in their metallurgy. Gaseous or molten fluorides affect it markedly, however, likewise bisulphates, but as there are only a few substances inert to such corrosive compounds, this can be hardly cited as a detrimental feature.

As a protective coating or paint for ordinary fire brick exposed to the destructive action of acid fumes or slags, zirconia should find a limited application.

A suitable bonding medium for such a purpose might be found in a weak solution of water glass or sodium silicate.

All bonding material must be used advisedly, as they naturally tend to lower the fusing point of the refractory. In lining furnaces or other metallurgical apparatus, natural zirconia can be mixed with water-free tar as a binder, in which case wooden forms are generally used. These are allowed to remain in place and consumed during the initial heat. The temperature should be raised very slowly at first to eliminate the volatile products in the tar, after which a temperature of at least 1400 deg. C. must be maintained for about 48 hours. Natural zirconia begins to fuse at about 1800 deg. C., and at 2000 deg. C. there is a noticeable volatilization of silica and other impurities.

In the manufacture of natural zirconia brick, muffles, crucibles and small articles of refractory ware, about 2 per cent of air-slacked lime as a binder has been used with success. In practice, a batch composed of 75 per cent 100-mesh zirconia, 23 per cent of 10 mesh, and 2 per cent of slacked lime, is worked into a plastic with a 3 per cent solution of 38 deg. Bé. sodium silicate. The bricks or ware are then pressed from this and allowed to thoroughly dry in a warm atmosphere. The procedure from this point on is the same as in the burning of ordinary refractories, except that a temperature of at least 1400 deg. C. is necessary to secure the proper vitrification.

As the density of zirconia is rather high (about 4.2), it has been suggested where imperviousness is not desired, that the incorporation of certain organic substances or volatile salts which would be destroyed during firing, thus producing small air cells, might serve to lighten the finished product without impairing its effi-

²Ruff, Lieferheld & Bruschke, Zeit. anorg. Chem., p. 389, 1914.

³German patent No. 262,009.

⁴Private communication.

ciency. Sawdust, cork dust or certain ammonium salts might prove of value for such aeration.

The low coefficient of expansion renders zirconia ware free from all danger of fracture due to sudden changes of temperature. In this respect it resembles fused silica ware.

The cost of zirconia as compared to certain artificial refractories produced in the electric furnace is considerably lower, which, in view of its remarkable properties, should commend it strongly to the furnace man or metallurgist.

Foots Mineral Company,
Philadelphia, Pa.

The Analoid Method for the Determination of Manganese in Steel, Iron Ore and Slag

The Scientific Materials Company, of Pittsburgh, Pa., through its research department, has recently taken up the problem of standardization of analytical methods for iron and steel laboratories. The first method undertaken was the determination of manganese.

The method selected as basis is the "Walters" or "persulphate" method, as it was considered preferable for routine analysis to any other, and as its general scheme is being practiced in a majority of iron and steel laboratories.

This method in brief consists of dissolving sample in nitric acid, adding measured amounts of silver nitrate and ammonium persulphate, holding the solution at about the boiling point until the oxidation of the manganese to permanganic acid is complete and finally cooling and titrating with a standard solution of sodium arsenite.

In the analoid method all the good points of the Walters method are retained, the operations standardized and at the same time simplified, by the application of the "analoids."

An "analoid" is a tablet containing just the exact quantities of the proper reagents, which have been carefully tested and apportioned to give the very best result for a certain reaction in the method for which it has been specially prepared.

Method for Steel and Wrought Iron

Sample: 0.1 gram. for percentages of Mn from trace to 1.10 per cent.

Place in a 6-in. by 1-in. test tube. Measure on to sample, with dispensing burette, 10 cc of 1.10 sp. gr. nitric acid (one part HNO_3 of 1.42 sp. gr. to four parts water). Place in boiling water in carbon boiler. When the solution is complete, without removing from boiler, add one 8-A analoid (silver nitrate). This will dissolve immediately. Add one 8-B analoid (ammonium persulphate). One minute from the time the pink color first appears, remove the test tubes from the boiler and place in water bath to cool. When at room temperature, wash into a 4-in. porcelain dish with 15 cc to 20 cc of water and add 3 cc of sodium chloride solution (5 grams per liter). Titrate with N/100 sodium arsenite solution* until the pink color is just discharged.

The addition of the sodium chloride solution is recommended as stated above, since it materially sharpens the end point.

* The N/100 sodium arsenite solution is made up of 0.491 gram of As_2O_3 dissolved in 2 or 3 grams of sodium carbonate and hot distilled water, cooled and then made up to one liter with cold distilled water. Standardize against a steel of known manganese content. The sodium chloride solution is used in standardizing. For a 0.1 gram sample the N/100 sodium arsenite solution should equal about 0.11 per cent manganese per c.c.

Method for Cast Iron, Pig Iron and All Slags

(For percentages up to 4 per cent.)

Sample: 1 gram. if from trace to 2 per cent Mn, or $\frac{1}{2}$ gram. if from 2 per cent to 4 per cent Mn.

Place in a 300-cc beaker. Dissolve in 40 cc HNO_3 sp. gr. 1.20 (one part HNO_3 1.42 sp. gr. to one part H_2O). Simmer until all soluble matter is dissolved. Dilute filter and make up to 250 cc, mixing thoroughly. With pipette take 25 cc, and run into a 6-in. by 1-in. test tube and proceed as before but add two 8-A analoids (silver nitrate) and two 8-B analoids (ammonium persulphate).

Titration: Rinse into a small conical flask, dilute to about 60 cc. Run in 3 cc sodium chloride solution and titrate with N/100 sodium arsenite until pink color is discharged.

Slags containing sulphides should be boiled three or four minutes after solution is complete, to insure all sulphur being oxidized. In dissolving, to prevent clotting, add first a little water and when boiling, add acid slowly. If any tendency to clot appears throw out sample and start another with more water.

Method for Ores

Sample: 1 gram. if from trace to 2 per cent Mn, or $\frac{1}{2}$ gram. if from 2 per cent to 4 per cent Mn.

Place in a 4-in. evaporating dish. Dissolve in 20 cc of HCl sp. gr. 1.18. Simmer until soluble matter is dissolved. Add 2 cc to 3 cc of hydrofluoric acid. Simmer until silicates are decomposed.

Add carefully 15 cc concentrated H_2SO_4 . Evaporate to fumes of sulphur trioxide. Cool, dilute to 40 cc with water, and boil until all the soluble matter is dissolved. Filter and make up to 250 cc. Proceed exactly as for cast iron, etc.

The Analoids

The matter of preparing suitable analoids was a far more difficult chemical problem than might at first be supposed. It was finally solved in the laboratory of C. H. & N. D. Ridsdale, the distinguished English iron and steel chemists.

The purity of the chemicals which enter into the analoids is first tested and the method of preparation is the same as employed in the dispensing of poisons, where very minute quantities are equally apportioned in each tablet.

The binders used in preparing the analoids preserve the reagents employed, so that they keep almost indefinitely.

The "analoid" method first embodies all the advantages of the "Walters" or "persulphate" method, but the number of operations has been decreased and at the same time the precision with which each operation is performed has been greatly increased by using analoids.

In this method, the measuring out and adding to the determination of an amount of silver nitrate solution is entirely eliminated. This operation took some time and as practised in many laboratories was done inaccurately and delayed the operation because the aqueous solution of silver nitrate cooled the determination.

Furthermore, the operation of first making the silver nitrate solution is entirely eliminated, which had to be done quite frequently on account of the instability of the solution.

The possibility of error in results by using a silver nitrate solution which should have been discarded, is eliminated and, of course, the waste incurred by constantly disposing of the old solution is also done away with.

In the analoid method the addition of an 8-A (silver

nitrate) analoid, which instantly dissolves, completes this operation.

In the old method the next operation is the addition of ammonium persulphate. This was done either by adding a solution or by adding the slightly moistened salt. The solution method requires weighing, and new solutions must be made frequently and the unused portion of the old solution discarded, as it quickly spoils. Often the solution is used when it should have been discarded and results are correspondingly incorrect. Time is lost owing to the necessity of measuring and adding the solution and the reaction postponed on account of the cooling effect on the determination.

The dry-salt method requires the weighing of each addition if the analyst is exact, but ordinarily the measuring is done by spoon, which, of course, is not exact. The operation is what is known in the laboratory as sloppy, because of the spilling and the sticking of the salt to the sides of the container in which the determination is being made. To correct this, the wash bottle is used, which takes time and changes the dilution of the sample.

When oxidation seems to be complete, the sample is removed from the source of heat. Some chemists perform the above-mentioned operation when sample is removed from source of heat and trust that the heat of the solution will be sufficient to complete the reaction. This, however, is not in accordance with the work of the more careful analysts who hold the determination at 100 deg. C. until oxidation is complete.

By the analoid method, one 8-B (ammonium persulphate) analoid is added, which acts immediately, and one minute later the test tube is removed from the water bath and cooled.

From this point the analoid method is the same as the Walters method and is finished by titrating the permanganic acid with standard sodium arsenite.

The time required for one determination by the analoid method is about nine to ten minutes including weighing, and for ten determinations about twenty minutes. For a great number, the time required may be figured at one minute per sample for the weighing and a further allowance of twenty-four to thirty minutes made for the manipulation, on a lot of fifty samples. With the exception of the weighing, the time required by the other method, as usually practiced, is at least twice as great.

In the analoid method every sample is treated exactly in the same way, whereas if the same precision were reached by the old method, the time required would be many times greater. In practice precision has usually been sacrificed for speed.

By diminishing the number of operations, as is done by the analoid method, the amount of apparatus required is also diminished, which permits the chemist to keep much neater and better appearing hoods and work benches.

This method is conducive to more accurate and careful work on the part of the operator because of its neatness and the fact that the necessity of hurrying is eliminated.

The Scientific Materials Company is extending the application of the analoid method to other routine analyses in iron and steel laboratories.

A New High-Pressure Gas Valve

In valves for high-pressure gas cylinders the safety features are very important. The valve must be free from leaks and easy to operate and it should last a reasonable time. The International Oxygen Company, of Newark, N. J., as a large shipper of oxygen and hydrogen in cylinders, experienced in the early days considerable trouble with valves. They found, for example, that the average valve, even though made tight at the start, would not remain tight under high pressure.

This occasioned losses from leakage sometimes as high as 25 per cent of the contents of the cylinder. Moreover, the packing in the valves was a source of trouble and if made of an inflammable material, such as leather, would even be a source of danger. The International Oxygen Company finally decided to take up a systematic research to develop a valve that would meet all requirements. As a result of a long series of experiments they evolved a high-pressure stud valve which is admitted to be unique, embodying principles of design and construction which are entirely original and eliminating the various objectionable features which caused their early troubles.



FIG. 1—HIGH-PRESSURE GAS VALVE

The I. O. C. stud valve can be used for pressures up to 2500 lb. It is specially recommended for oxygen, hydrogen, nitrogen and similar gases. It is made of non-corrosive metal throughout, no packing being used in any part. The body is forged tobin bronze, while the other parts are made of suitable metals which are non-corrosive to gases or to any weather conditions. Figs.

1 and 2 show the simple construction of the valve. Every part is accessible and if worn out can be easily replaced at little expense.

The diaphragm is made of very tough and springy material that will withstand perfectly all the strain put upon it, without any possibility of its cracking or breaking even after many years of service. The diaphragm takes the place of packing material, and in this way the usual stuffing box is entirely eliminated. In the case of high-pressure oxygen gas, the studding box is extremely objectionable, as one must resort to the

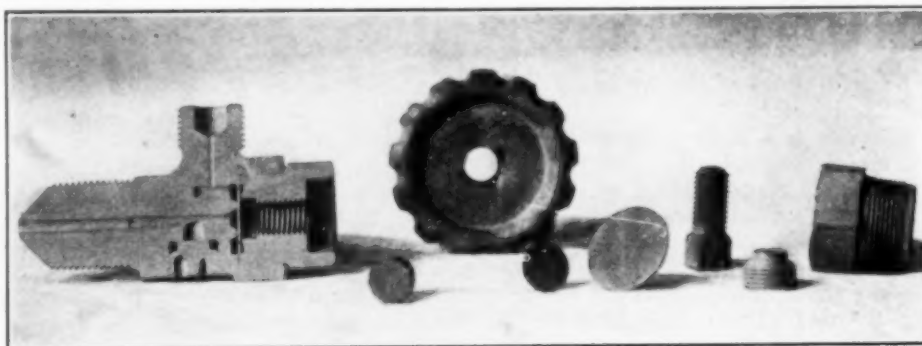


FIG. 2—SECTIONAL VIEW AND PARTS OF HIGH-PRESSURE GAS VALVE

use of rubber, leather or similar inflammable materials.

The diaphragm is slightly concave, and is normally set away from the seat of the valve a sufficient distance to permit a full opening of the valve. It is not necessary, therefore, for the gas to raise the diaphragm; in this way all the gas from the cylinder can be used, down to atmospheric pressure.

An essential part of any high-pressure valve is its safety plug. In the I. O. C. valve this is an ingenious device which has received the approval of the Bureau of Explosives of the Interstate Commerce Commission. The plug is filled with fusible metal melting at, or below, the boiling point of water. It is provided with three passages, each in a straight line with the direct action of the gas in the cylinder to permit the outflow of the metal; is further provided with a hemispherical seat and a phosphor bronze disk. This safety plug is screwed into the body of the valve and forms a tight seat by compressing the phosphor bronze disk. No part of this plug projects beyond the body of the valve, this protecting it against breakage. The safety plug will not blow when submitted to the direct rays of the sun or any other atmospheric condition; but will blow when placed in a fire, before the expansion of the gas can do any damage to the cylinder.

This valve has been in use in the Newark works of the International Oxygen Company for a number of years and a great many valves are used by other gas manufacturers in this country and Canada. The valve has given entire satisfaction under all conditions of severe laboratory tests and of actual commercial service.

A New Vacuum Pump for Vacuum Heating and Vacuum Filtration Systems

A novel vacuum pump has been put on the market by the Nash Engineering Company of South Norwalk, Conn., for use in connection with vacuum heating systems, vacuum filtration, or wherever air containing a large percentage of liquid has to be handled. The primary object of a vacuum pump in a heating system is to rapidly remove the air which is very detrimental to the efficiency of the system. The pump should do this with-

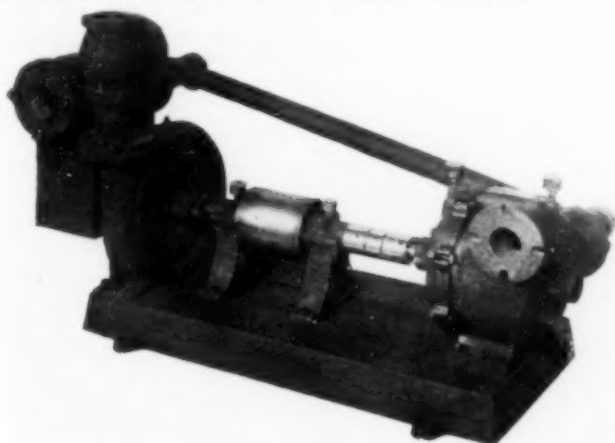


FIG. 1—HYDROTURBINE AND CENTRIFUGAL SET

out the necessity of introducing cooling water with consequent loss of heat. This is very effectively accomplished by the Nash hydroturbine.

Fig. 1 shows clearly the various parts. A Nash hydroturbine and Gould centrifugal are mounted in line on a cast-iron base. A separator is connected at the bottom to the centrifugal and near the top to the Nash pump. A check valve is placed on the outlet of the centrifugal.

The action of the outfit is as follows: As soon as the shaft is rotated the Nash hydroturbine produces a vacuum in the system, which draws water and air into the separator. The water falls to the bottom of the separator and is discharged by the centrifugal. The air is drawn from the top of the separator by the Nash pump.

As the amount of water handled varies, the centrifugal is made large enough to take care of the maximum quantity. When less water than this comes along the centrifugal continues to pump water until the separator is empty. The centrifugal then ceases to deliver water, but the check valve on the outlet prevents the vacuum from being broken.

As soon as the water has accumulated in the separator sufficiently to submerge the inlet, the centrifugal once more takes hold and pumps the water out.

The advantages of this simple combination are at once apparent. The water and air are handled separately in pumps specially designed for the purpose, the air in an air pump, the water in a water pump, which means greatly increased efficiency. The water may be delivered efficiently against a head without putting any back pressure against the air pump, which means a big saving in power as the air pump is of relatively large vol-

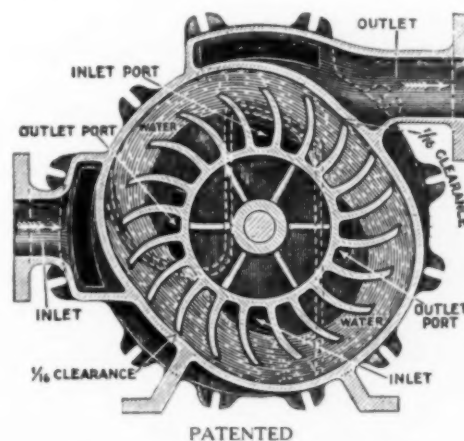


FIG. 2—CONSTRUCTION OF PUMP

ume as compared with the water pump. It is possible to handle water containing dirt and abrasive material, as this all passes through the centrifugal, which is adapted for this service, and furthermore may be replaced at small expense if it finally is worn out.

An examination of Fig. 2, illustrating the interior of the Nash pump, shows the simple and efficient principle upon which it works and why it is specially adapted to the service described above.

The water follows the case, due to centrifugal force. Twice in a revolution the water recedes from the rotor, thereby leaving spaces between the blades into which air is drawn through the inlet ports. The water then surges back into the rotor, compressing and delivering the air through the outlet ports. The water seal prevents leakage. The water is used continuously. The suction is uniform. The pressures on the shaft due to compression are balanced. There are no valves or loose moving parts. The rotor is the only moving element and is fitted with ample clearance.

The large volume of air handled by the Nash pump keeps the centrifugal primed and free from air, which means that it works at its highest efficiency. The large volumetric capacity also makes it possible to produce a vacuum when handling extremely hot water. Under this condition the action of the pump is as follows:

The vacuum rises until the point is reached where the

water becomes steam at the existing temperature. The Nash pump takes the steam away as fast as formed. The steam is drawn into the pump under a vacuum and is compressed by the pump and delivered at atmospheric pressure.

As the steam is compressed some of it condenses and is delivered as water.

The reliability of this outfit is one of its strongest points, as both pumps have only one moving part, running with a clearance. There are no valves or piston packing to require attention.

The machine shown in Fig. 1 is arranged for belt drive. It can also be built for direct connection.

A New Water Still

The following article describes a new water still involving several interesting novel features. It is built by the A. P. Link Manufacturing Company, 212 Thirty-ninth Street, Brooklyn, N. Y.

The still is shown diagrammatically in Fig. 1, with the boiler at the left and the condenser at the right. An outside view of the still is shown in Fig. 2.

The apparatus is made entirely of copper, heavily tinned with pure block-tin, and has an easily removable

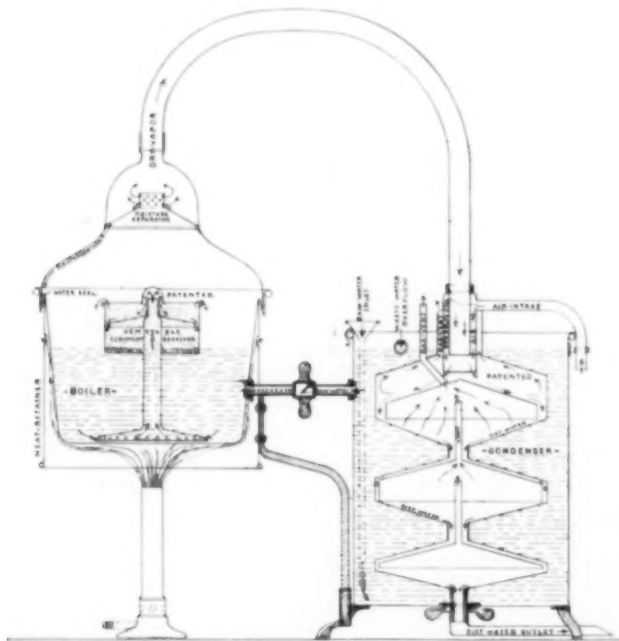


FIG. 1—DIAGRAM OF WATER STILL

sediment receiver which can be conveniently placed inside of the boiler where it keeps the water in constant circulation from the outside towards and up through the center, depositing all the sediment in a sediment cup, thereby preventing the settling of any sediment and any encrustation along the boiler surfaces. By these means also a larger steaming surface is obtained than can be produced with a flat boiling surface only.

The water in the boiler is constantly kept at its proper level by means of a very simple hinge check valve, which permits the water to flow from the condenser to the boiler (from right to left in the diagram) but not in the opposite direction, so that it is impossible for undistilled water to pass over to the condenser.

The water before entering the boiler is pre-heated by the steam from the boiler and can be kept at any desired temperature so as to free the water from a great amount of ammonia and other gases before it is admitted to the boiler.

Another novel feature in the boiler is the provision which has been made to separate moisture (which is more or less contaminated) from the splashing bubbles which are projected against the inner surfaces of the cover or other parts of the boiler so that this moisture cannot be entrained into the condenser whereby naturally the distilled water would be rendered impure to a certain extent. This feature has also been well tested out and found very successful in eliminating all moisture from the vapors before they leave the boiler cover. Such moisture is returned to the boiler immediately by its own gravity, and without loss of heat units.

The vapors arriving at the condenser neck can be permitted to syphon an abundant amount of free air which is sterilized around the steam pipe proper, within the condenser neck. The air is finally mixed with the steam and water while projected against the walls of the condenser, which are surrounded by water. The water vapors are immediately condensed while the remaining gases are liberated according to their specific gravity in a discriminating manner at various points, which is accomplished without loss of water vapor. This air syphon is made use of when well aerated water is desired for drinking purposes. If non-aerated water is desired, all that is necessary is to stop up the air intake, whereas the elimination of all the gases is never interfered with.

The second venting tube is at the same time an indicator for the operator if the water in the condenser should become too hot. In this case this vent tube shows a slight escape of steam, so that by this means the proper temperature of the condensing water can be easily obtained, or the apparatus so operated as to eliminate any and all gases according to the temperature at which the condensing water is being kept.

It is obvious that with this apparatus, even very polluted water can be distilled to absolute purity. The distilled water leaving the condenser at the bottom is cool, practically at the same temperature as the raw water fed through the inlet.

The raw water from the inlet is always projected against the lowest part of the condenser, whereby the temperature of the water on top of condenser can be constantly kept at the desired degrees to accomplish the desired results.

All parts of the still are easily accessible, can be readily taken apart and cleaned and re-assembled without delay, and without use of any tools or experience. The whole apparatus consists of *only five parts*, boiler, condenser, sediment receiver, cover, and vapor pipe. It is portable and can be readily set up and operated upon any shelf, a table, a stand, a stove, or wherever convenient or it can be set up permanently and connected with any gas, water and steam supply.



FIG. 2—OUTSIDE VIEW OF WATER STILL

A New Electrical Long-Distance Transmitting Indicating and Recording System

A new electrical long-distance transmitting indicating and recording system is being placed on the market by The Bristol Company, Waterbury, Conn. In these instruments Bards patent long-distance induction-balance movements are employed as especially developed for this purpose by the Sangamo Electric Company. Bristol recording instruments, when equipped with these electrical transmitting systems, are capable of

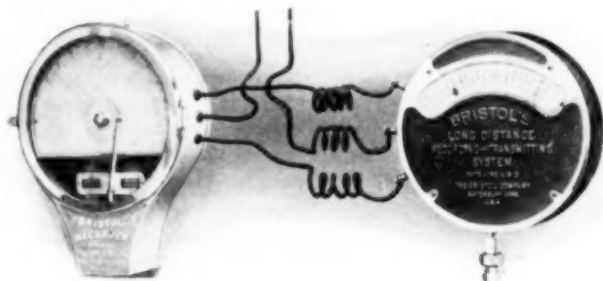


FIG. 1—STANDARD UNIT OF TRANSMITTING AND RECORDING INSTRUMENT

producing automatic and continuous records of pressure, liquid levels, temperatures, mechanical motions, etc., at long distances, even many miles from points at which the transmitters are located.

Fig. 1 shows a standard unit of these transmitting and recording instruments, including the transmitting indicator for installation at the point where the pressure or temperature, etc., is measured, and the receiving recorder which is installed at the remote point

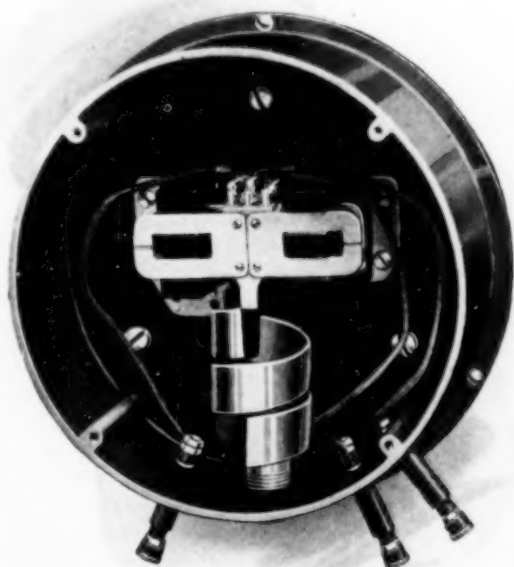


FIG. 2—INTERIOR OF TRANSMITTING INSTRUMENT

where it is desired to have the printed record produced.

The two instruments are shown connected by three wires, one of which is connected in the manner indicated to a source of alternating current, as for instance, a lighting circuit.

This long-distance system is particularly well adapted for use under ordinary operating conditions because of its simplicity of construction. There are no sliding

or make-and-break contacts employed, and the effects of variation of temperature or resistance along the circuit are negligible. The recording instrument may be installed many miles distant from the measuring and transmitting device. For instance, if 110 volts and No. 14 copper wires are used, the recorder may be located thirty miles from the transmitter, or if No. 12 leads are used the recorder can be installed forty miles or

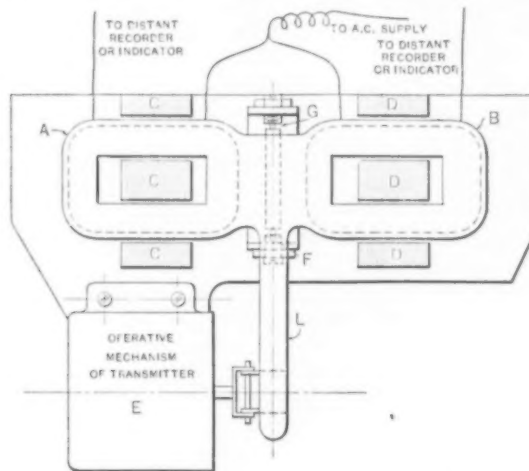


FIG. 3—FRONT OUTLINE DIAGRAM OF TRANSMITTING DEVICE

more from the transmitter. The transmitting device is mounted in moisture-proof case, and can be installed outdoors if necessary, as, for instance, on the bank of a reservoir.

One of the first outfits of these instruments was installed at Peoria, Ill., to indicate at the central station the steam pressure at the end of the steam-heating main, and the superintendent of the electrical department of the Central Illinois Lighting Company, by whom this was used, has made the following statement: "In regard to this particular outfit, which has been in service more than four years, two other systems were installed by us on the strength of the success by the first system, and all have given very good service." Over a dozen other sets of this equipment have also been in successful service for more than two years.

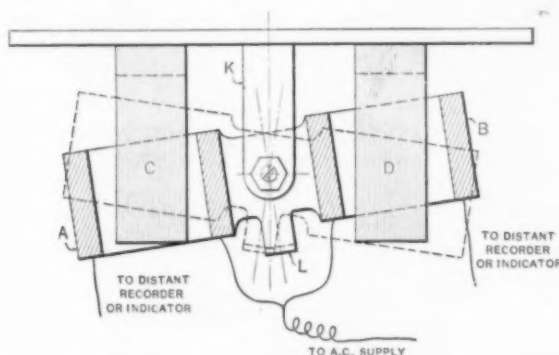


FIG. 4—TOP OUTLINE DIAGRAM OF TRANSMITTING DEVICE

The fundamental principle of the Bristol long-distance transmitting and recording system is that of the induction balance. The transmitting instrument and the receiving instrument are each equipped with two pairs of coils arranged to swing in a horizontal plane over iron cores. Fig. 2 shows the interior of one of the transmitting instruments. In this instrument the helical form pressure tube and the electrical transmitting device are shown in the operating position.

Figs. 3 and 4 are detailed front and top outline dia-

grams of the transmitting device, which is similar to the receiving device.

The complete outfit consists of two pairs of mechanically balanced solenoids arranged to swing horizontally back and forth over the ends of soft iron cores and connected in parallel to an alternating-current circuit. One pair of the solenoids is used for the transmitting instrument, the other pair for the receiving instrument. Front view, Fig. 3, of the transmitter shows one pair of the solenoids A and B on spools connected together and supported on a shaft, the ends of which rest in jewel bearings at G and F and free to swing back and forth over laminated soft iron cores C and D. The top view, Fig. 4, shows the solenoids A and B of the transmitter in section and by the dotted outline the position to which the solenoids may swing is also indicated.

A similar pair of balanced solenoids is placed in the receiving recorder or indicator at the distant point. When the solenoids A and B of the transmitter and receiver are connected in parallel to an alternating-current circuit and the transmitter coils A and B are held in some certain position by the operating mechanism located at E (water level gauge, pressure gauge, thermometer, etc.), the relative amounts of current flowing in solenoids A and B will depend on their positions on the iron cores C and D due to the inductive effect of same.

At the receiving instrument the other pair of solenoids are mechanically balanced and free to take an angular position which will be the same as that of the transmitter since the flow of current will be the same in the corresponding solenoids of the receiver as in the

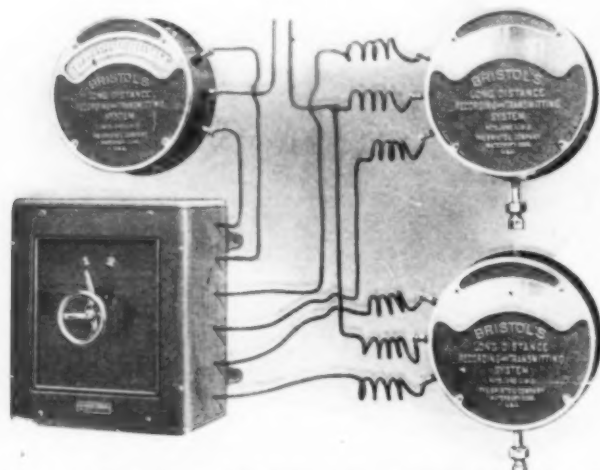


FIG. 5—COMBINATION OUTFIT OF TWO TRANSMITTERS AND ONE RECEIVING INDICATOR

transmitter. If the angular position of the pair of solenoids at the transmitter is changed by the operating mechanism thus moving one of the solenoids off and the other on to the iron cores, increasing the inductance in one solenoid and diminishing it in the other, the flow of current will be proportionately increased in one coil and diminished in the other. The variations of current at the distant receiver will correspond with the variations at the transmitter, and cause the pair of solenoids of the receiver to seek a position of balance which will be the same as that of the solenoids of the transmitter.

In the transmitter the operating mechanism is linked directly to the balanced solenoids by means of an arm L. In the receiver the recording pen or the indicating pointer is connected to a similar arm through a simple and practically frictionless multiplying mechanism.

Various combinations of transmitting and receiving instruments of either indicating or continuous recording type may be furnished. Fig. 1 illustrates the stand-

ard equipment including a transmitting indicator and a receiving recorder, but it is possible to furnish the transmitter and receiver in either the indicating or recording type. Fig. 5 shows a combination outfit including two transmitters and one receiving indicator connected with a two-point rotary switch so that readings may be obtained with the indicator of the pressures, temperatures, etc., from either of the transmitters.

A great variety of applications for this apparatus will arise owing to its flexibility and extreme simplicity.

Locomotive Cranes

The accompanying illustration shows in an interesting manner the efficient handling of bulk materials at a beet sugar factory by means of locomotive cranes. One of the cranes is being used to place coal in bunkers above the power house, while the other is unloading sugar beets from cars into the beet bin.

The beet harvest usually does not begin until about the middle of October and then the farmers try to deliver their beets before cold weather sets in, with the



LOCOMOTIVE CRANES AT SUGAR PLANT

result that there is usually a congestion at the factory of cars waiting to be unloaded. To relieve this congestion and because of the economy in the use many of the sugar factories are using locomotive cranes. Such excellent results have been obtained that one company said their crane paid for itself the first year, since then they have purchased two more cranes.

A carload of beets a day is about all a laborer can unload by hand, while three men and a crane will unload from three to four cars an hour. In addition to the saving effected the crane does its own switching of cars so that rapid unloading is greatly facilitated. The crane in the foreground is using the special beet fork built so as not to crush the beets when handling them. Beneath the beet bins there are sluices to allow the beets to be transported to the factory by a rapid current of water.

Just before the picture was taken the farther crane loaded two 40-ton cars with coal from a reserve pile in twenty-five minutes. It then brought one of them around to the power house and placed the coal in elevated bunkers as shown. It also handles beets and limestone and is otherwise generally useful around the factory. The picture was taken at the plant of the German American Sugar Co. at Bay City, Mich., the locomotive cranes being made by the Industrial Works of the same city.

Automatic Sampling of Mill Pulps

The automatic sampler described in this article is the design of Mr. Elmore and is being built by Messrs. F. W. Brackett & Co., Ltd., Colchester, England. The construction of the Elmore sampler is shown in the adjoining illustration.

It is to be noted that the sampler can be set with driving shaft at any angle in relation to the launder conveying the pulp to be sampled. By simply sliding the adjustable arm on the center pin, the machine is at once adapted to various widths of launders.

The sampler is put into operation by motion imparted through a round belt on the grooved pulley *Q* which is keyed to the shaft *P*; this in turn rotates the worm engaged with the worm pinion. This worm pinion operates an eccentric (not visible on the illustration) which reciprocates the pawl *R* causing the main ratchet wheel *O* to advance one tooth at a time. Thus the main ratchet wheel *O* is caused to rotate slowly.

To the upper face of *O* a toothed segment *N* equal to about one-sixth of the periphery of *O* is securely at-

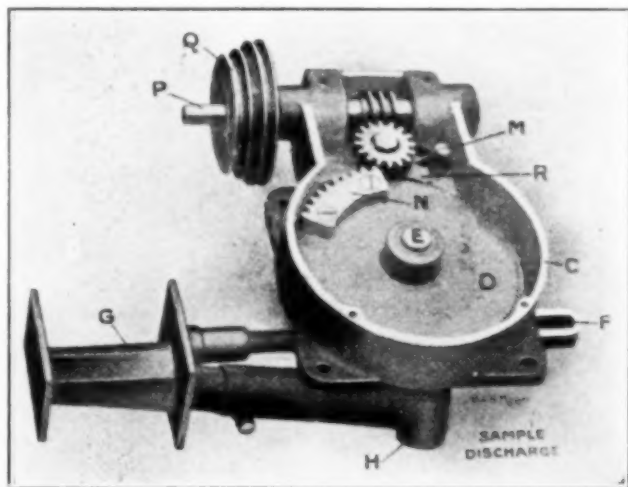


FIG. 1—AUTOMATIC SAMPLER

tached, the teeth of which are of the same pitch as those of the worm pinion. By the slow rotation of the main ratchet wheel *O* the segment *N* gradually approaches the worm pinion and engages with it, which immediately results in the quick movement of *N* and *O*; and as these carry the pin *E* to which is attached the sampling cup and discharge pipe *H*, it follows that during about five-sixths of each revolution (the non-sampling period) the main ratchet wheel *O* is moving at a very slow rate, whereas, for the other one-sixth of the revolution (the sampling period) the rate of movement is high, and the sampling cup thus cuts through the whole stream of pulp at a perfectly uniform rate of speed, and always at the same relative angle, during the whole period of sampling.

All the bearings and moving parts are enclosed in a substantial outer casing *C* covered with a dust-tight lid thus forming an oil bath, and providing perfect lubrication, minimizing wear and tear, and insuring continuity of working.

Personal

Messrs. Ernest Bamberger, Duncan MacVichie and H. L. Lambrecht have been appointed by the United States District Court as appraisers of the tangible assets of the Ohio Copper Co.

Mr. H. J. Baron, manager of the Mexican Chemical Co., Chihuahua, Mexico, spent ten days in Denver last month in the course of a business trip to the States.

Mr. Fred W. Bradley, president of the Bunker Hill & Sullivan Mining Co., was tendered a reception recently at Kellogg, Idaho, at which he spoke enthusiastically regarding the development of the dry chlorination experiments that have been under way for some months past.

Mr. T. H. Davis has resigned his position as vice-president and general manager of the Rahway Chemical Co., of Elizabeth, N. J., and will manage the new plant of the Rahway Coal Tar Products Co., which will be in operation at Rahway, N. J., early next year. The new company is controlled by Merck & Co., of New York.

Mr. Philip DeWolf, chemical engineer, of Bristol, R. I., left for Memphis, Tenn., to investigate the possible local production of potassium salts, the supply of which to this country from abroad has been seriously curtailed since the beginning of the European war.

Mr. J. C. Farrant, European representative of the Hardinge Conical Mill Co., is a British prisoner at the Doberwitz detention camp near Berlin.

Mr. H. C. Hoover, who has been so prominent in the relief work in Europe since the opening of the war, is engaged in administering relief measures in Belgium.

Mr. A. J. Hoskin, of Denver, has been in the gold mining districts of Georgia on professional business.

Mr. John L. Malm has returned to Denver from Kellogg, Idaho, where he is engaged in consulting metallurgical work for the Bunker Hill & Sullivan Mining Co. He expects to resume his duties at Kellogg after a brief absence on other professional duties.

Mr. A. M. Plumb, of the technical staff of the American Zinc Ore Separating Co., has been transferred from Denver to Platteville, Wis., where he will be engaged in a consulting capacity on the separation of zinc ore at the mill of the Wisconsin Zinc Co.

Prof. Robert H. Richards will be tendered a complimentary dinner at the Copley-Plaza Hotel, Boston, on Monday evening, December 7, "in recognition of his fifty years as a devoted Tech man and in expression of the respect and affection in which he is held by the Corporation, Faculty and Alumni of the Massachusetts Institute of Technology."

Mr. James E. Russell has been appointed assayer in charge of the United States assay office at Deadwood, S. D.

Mr. Peter J. Weber, city chemist of the city of Milwaukee, has resigned to accept the management of the American Metal Products Company of Milwaukee.

Mr. Robert E. Wilbur has been appointed assistant to the general manager of the Bethlehem Foundry & Machine Company.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electroplating (Continued)

626,330, June 6, 1899, Carl Luckow, of Cologne-Deutz, Germany.

Relates to making peroxide of lead, and consists in electrolyzing a solution containing, say, $1\frac{1}{2}$ per cent of a mixture of ninety-nine and one-half parts by weight of sulfate of sodium and five-tenths part by weight of chlorate of sodium, using electrodes of lead. The current density should be $\frac{1}{2}$ amp per sq. decimeter at about 3 volts. To facilitate the reaction and to keep the electrolyte in motion, air is carefully blown in during the process.

629,070, July 18, 1899, Pompeo Garuti and Riccardo Pompili, of Naples, Italy.

Relates to generating oxygen and hydrogen by the electrolysis of alkaline hydroxide solutions, and refers to his prior patent No. 534,259, on which the present patent is an improvement. The improvement consists in perforating the lower part of the insulated metal diaphragm with many small holes, or not more than 1 mm diameter, which prevents any gas escaping from one side to the other, and reduces the electrical resistance of the cell. The electrodes do not extend below the upper row of holes in the diaphragm.

630,246, Aug. 1, 1899, Frank S. Loeb, of New Kensington, Pa.

Relates to preparing aluminium for electrodeposition. The aluminium is first cleaned of any dirt, grease, etc., and rinsed in hot water. It is then immersed in dilute hydrofluoric acid, containing 25 cu. cm to 2 liters of water, until hydrogen gas is freely evolved; it is then removed and at once immersed in a "quicking" solution composed of 50 gr. of mercury dissolved in 100 cu. cm of strong nitric acid, this being added to 2 liters of water, and 30 gr. of potassium cyanide added; about five seconds immersion is sufficient; it is then reimmersed in the hydrofluoric acid until hydrogen is evolved, and then transferred to an electroplating bath. For copper plating, the following electrolyte is used: 8 oz. of copper acetate is made into a thick paste with water, then add 8 oz. of sodium carbonate dissolved in 2 qt. of water. In a separate vessel, dissolve 8 oz. of sodium bisulfide in 2 qt. of water, and add this to the copper acetate solution; then dissolve 6 oz. of potassium cyanide in 3 qt. of water, and add to the previous mixture, then add 5 qt. of water, bringing the volume to 3 gal. The bath should be used hot, about 130 deg. to 180 deg. F. Directions are also given for making electrolytes for depositing brass and silver.

647,858, April 17, 1900, Eduard Mies, of Budesheim, Germany.

Relates to preparing aluminium to receive electrolytic deposits of other metals. The aluminium is heated for about five minutes in a boiling solution of phosphate of sodium and sulphate of magnesium, slightly acidulated with sulfuric acid, and then washed and then immersed in the ordinary electrodeposition baths as cathode and electroplated. The solution containing the phosphate of sodium, etc., probably corrodes or etches the surface of the aluminium, enabling the electrodeposited metal to adhere firmly.

653,715, July 17, 1900, Jean Theodore Van Gestel, of New York, N. Y.

Relates to an apparatus for producing a water-repellent surface on cloth or similar fabric, by immersing the cloth in a tank of water through which an electric current is passing, and then passing the wet cloth between one or two pairs of traveling metallic belts, the first pair so connected electrically that a current passes through the cloth in one direction, thereby producing a water-repellent surface on one side, and the second pair so connected electrically that the current passes through the cloth in the opposite direction, thereby producing a water-repellent surface on the other side. The traveling belts consist of upper and lower horizontal belts, each made of pieces of metal united with hinge joints, zinc being used as the anode, and copper for the cathode. The belts of each pair are supported on polygonal rolls driven by link chains and gearing, electrical contact being made with the belts by rollers for the upper belt and supporting pressure surfaces for the upper side of the lower belt. The lower side of each lower belt travels through a tank containing water which serves to wash off any impurities that

may have collected thereon. The belts may be covered with a layer of cotton cloth to prevent short-circuiting. A pair of rubber rolls remove any surplus water from the cloth after treatment. (See patent 653,716.)

653,716, July 17, 1900, Jean Theodore Van Gestel, of New York, N. Y.

Relates to rendering cloth and similar fabrics waterproof and to setting the dye therein. The cloth is immersed in a solution of a metallic salt or salts and then subjected to the action of the electric current which causes an oxid of the metal to be formed in the interstices of the fabric. In fixing a dye the metallic salts are applied to the fabric either with the dye, or to the already dyed fabric as above described. For white goods a soluble salt of any suitable metal that will produce a white oxid, such as aluminum, is used, while for dark goods a soluble salt of a metal that will produce a dark oxid, such as iron, is used; and for goods of other colors, the soluble salt of a suitable metal such as will not change the color, may be chosen in accordance with well-known coloring properties of metals. The apparatus used is substantially the same as in patent No. 653,715.

Book Reviews

The Cleaning of Blast-Furnace Gases. By Frederick H. Wagner. 168 pages, 58 illus. Price, \$2. New York: McGraw-Hill Book Company, Inc.

A very timely work, in view of the fact that the subject is continually claiming increased attention. The chapters deal with the theory of condensation and cooling, dry dust catchers, wet cleaning, final cleaning, operative plants in America, and the storage of gas. These are all admirably handled except the theory of cooling and condensation, which contains too much of the academic theories of Dr. W. Feld. The four deductions on page 14 regarding infinite volume and infinite heat capacity of certain mixtures of gas and water vapor are neither pertinent, useful, nor instructive. The other chapters are all commendably good.

Fuel: Solid, Liquid, and Gaseous. By J. S. S. Brame. Octavo (14 x 22 cm.), 372 pages, 70 illustrations; price \$3.50 net. New York: Longmans, Green & Co. London: Edward Arnold.

The author is lecturer on fuel at the Royal Naval College, Greenwich, and this volume is intended primarily to consider fuels in their relation to power, but their application to other purposes has not been omitted. It is intended primarily for engineers and technical men to whom the production of power is of importance.

It is a very satisfactory and useful book. The author discusses the composition, properties and calorific values of the different fuels in a masterly manner, which is commendably scientific as well as highly practical.

The only serious slip found was that the author seems unaware that the specific heats of gases at high temperatures are now known with fair accuracy, rendering possible satisfactory calculations of maximum flame temperatures. Using the old specific heats, which lead to impossibly high temperatures, he properly brands the results as absurd, and then dismisses the whole subject. The book would be improved by a short chapter on this topic.

The burning of coal dust is not given as much prominence as its successful applications in America to cement and metallurgical furnaces would warrant.

Aside from these two items the work is very well written, and as a whole it is strongly recommended to all interested in fuels and their investigation.



By advanced methods, we have so improved the quality and lowered the cost of large electrodes that they are finding more extended application in all of the chief branches of electrothermic work.

In fact, Acheson-Graphite Electrodes are becoming as favorably known in electric furnace work today, as they have been for years in the electrolytic field.

Steel and iron, zinc, carbide, ferro-alloys, silicon—are all made in furnaces employing Acheson-Graphite Electrodes. They are higher in first cost than some other electrodes, but, just as is the case with so many other things you buy, **they are cheaper in the long run.** This is due to their durability and their consistently high quality—their uniformity.

Just now, when some European sources of electrode supply are cut off, it is pertinent that the supply of Acheson-Graphite Electrodes is practically unlimited.

We will make your individual need our specialty.

On request we will gladly send you either of the following booklets covering the use of Acheson-Graphite Electrodes in electrothermic work:

English 452-I

French 453-I

German 454-I

International Acheson Graphite Company

Niagara Falls, N. Y.



PUBLISHER'S PAGE

“What is the Trend in Advertising?”

Was recently asked of an advertising man.

His reply was this:

“Advertisers are beginning to realize that in order to make their advertisements generally read they must make their advertisements generally helpful to the reader—must make the reading of them worth-while.”

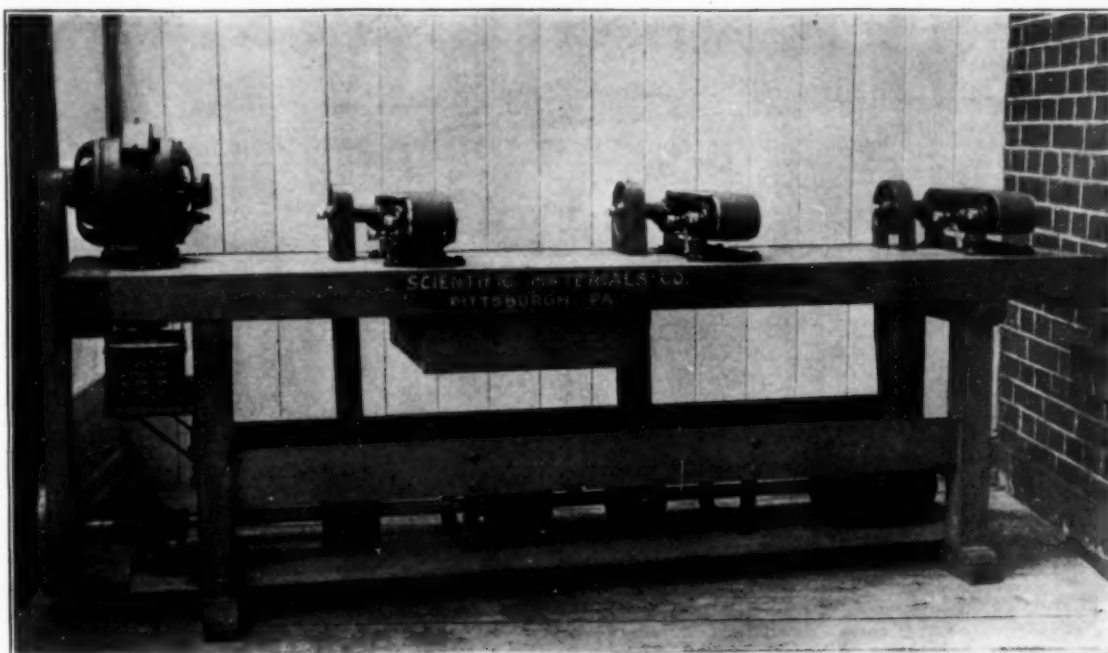
This, precisely, is what advertisers in technical magazines like Metallurgical and Chemical Engineering have for a long time realized.

Most of the advertisers who use Metallurgical and Chemical Engineering can help readers through their advertisements.

Not only can they help them by keeping them in touch with the newest devices on the market, but they can point out troublesome conditions which can be overcome by the use of advertised products.

Readers of such advertisements therefore learn not only of better ways to do things they are doing now, but also ways of doing desirable things now left undone.

The more you investigate the vast fund of useful ideas to be found by those who seek them in the advertising pages of Metallurgical and Chemical Engineering, the more will you become convinced that reading advertisements is distinctly worth your while.



Our New Metallographic Grinding Machines

of the endless belt type have been specially designed to permit the grinding **in straight lines** and to obtain **perfectly flat surfaces**, in accordance with our improved method of preparing metal specimens for microscopic tests. This method will be found to be far superior to the old way of grinding specimens by holding them against rotating wheels, whereby uneven and torn surfaces are created. Our new machines are equally suitable for the grinding of small specimens and of large pieces, such as rail sections, etc., the grinding space being $3\frac{1}{2} \times 10$ inches.

The readily interchangeable grinding belts offered by us for use with our metallographic grinding machines are specially made of carborundum cloth and bauxite cloth of carefully selected quality. We can supply these belts in all degrees of fineness and shall be glad to suggest the correct grinding cloth to meet our customers' individual requirements.

We offer these machines single or mounted on benches in any desired number, with or without electric motor drive. Detailed quotations will be submitted on request.

Our own Metallographic Laboratory, maintained for the sole purpose of demonstrating our improved metallographic apparatus and methods, is one of the best equipped in this country. Our large practical experience in this field is at the disposal of our customers.

Scientific Materials Company

Pittsburgh, Pa., U. S. A.

Manufacturers of Scientific Apparatus for Laboratories and Industries

PUBLISHER'S PAGE

(Special)

The American Ambulance Hospital in Paris

Metallurgical and Chemical Engineering is glad to give circulation in this way, to the following announcement:

THE UNUSUAL WAY

To interest you in the remarkable work of the *American Ambulance Hospital in Paris*, which is relieving the wounded of all nationalities injured in the Western Theatre of the War, we have chosen a businesslike way to solicit your interest and to appeal for your support.

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A motor ambulance service with field surgical corps has been added, which insures more prompt attention to the injured and their rapid transfer from battlefields to base hospitals. This unique feature has called forth the praise of the highest medical and military authorities.

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It is the belief of the *American Chamber of Commerce in Paris* that all Americans will wish to aid this splendid work of their compatriots, and make possible the urgent extension of present capacity of 400 beds to the capacity of the building—1000. In Paris about \$120,000 has already been raised. In this country about \$140,000 had been contributed up to November 5th. A further \$300,000 is urgently needed.

No administration expenses,

No salaried secretaries or clerks,

No paid officers

in connection with the collection of funds. Every dollar contributed is of full value in immediately relieving distress and suffering on the battlefields and in the hospital.

Here is a Direct Object, a Noble Purpose and a Practical American Institution for the Relief of Wounded Human Sufferers.

ONE DOLLAR WILL CARE FOR A WOUNDED SOLDIER ONE DAY.

Contributions may be sent through **J. P. Morgan & Co., 23 Wall Street, New York**, direct to the American Chamber of Commerce in Paris, or to the undersigned.

FRANCIS E. DRAKE, Second Vice-President,

14 Wall Street, New York.



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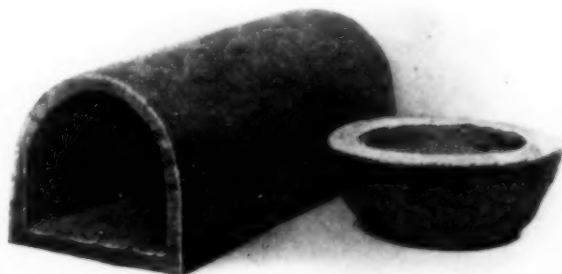
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A NEW REFRACTORY BODY

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65-70% Ferro-Chrome (of the usual and lowest carbon contents) and "ELECTRO BRAND" 50% Ferro-Silicon always in stock in this country for immediate delivery.

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96-98% Tungsten, Max. 0.25% Carbon

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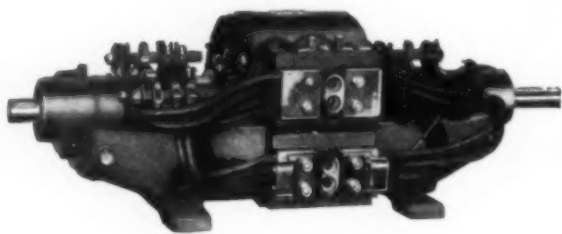
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Brush holders are perfectly accessible and long life metite brushes are used, eliminating sparking and cutting of commutator.

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you'll want to use it too. It is the newest, simplest and most improved gas valve made. No packing, no leakage, no waste, no repairs, no trouble, no expense. Safety Device Perfect. Approved by Bureau of Explosives of the I. C. C. Send for prices and full particulars.

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THE BEST PROOF

of the *NEED* for the Searchlight Section is the large number of requests constantly received by the publishers for information as to where second-hand machinery or certain services can be obtained.

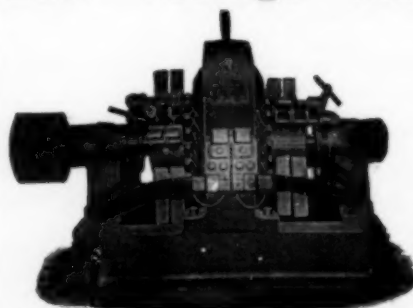
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is now the market place where these wants can be made known and filled.

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Up to 10,000
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Single, two and three voltages for School and Laboratory work. Deposition, Refining and Separation of metals.

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are now available of sizes with capacity
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These electric stills are intended for use in industrial plants and institutions having their own isolated power plant; using central station power at current rates makes the cost of distilled water prohibitive.

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Barnstead Electric Stills are equipped with heating units fitted into the boiler, so that they are surrounded with the water. These units if kept covered with water will last indefinitely; they are easily and inexpensively replaceable in case of need.

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All types produce automatically and continuously water of the highest degree of purity, free from ammonia and all gaseous and organic impurities.

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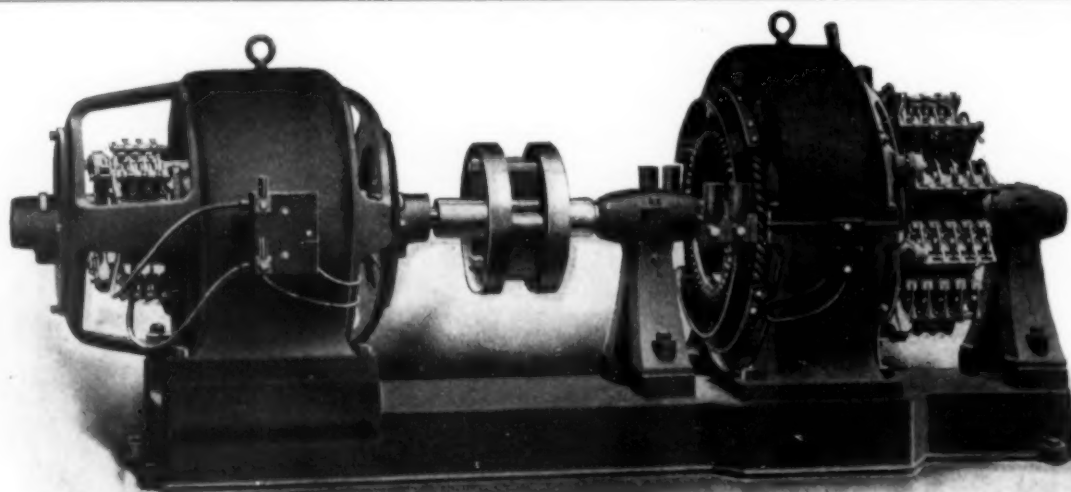
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Let our engineers confer with you upon transformer problems.

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Savings up to 30-40%
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As these furnaces are manufactured in the United States
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Runs on an Overhead "I" Beam and Occupies No Floor Space

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You can "cash in" on our experience. Our broad survey of the field has enabled us to benefit by experiences that have proved costly to others. If you are a fire brick user let us extend the benefit to you.

Brighton Fire Brick Company, New Brighton, Pa.

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**"The best thing we ever came across
to keep the heat confined"**



Tank Furnace Insulated with Nonpareil Insulating Brick

Loss of heat means waste of fuel—waste that can be stopped, too. If the walls and arches of your furnaces, ovens and boiler settings are insulated with a 4½-inch course of Nonpareil Brick the greater part of the heat now lost by radiation will be saved. The saving in fuel which results will be noticeable right from the start. This reduction of heat loss will also save money by providing more comfortable working conditions for your men. Better working conditions mean increased efficiency and production.

That is what the Glenshaw Glass Company, Swedesboro, N. J., wrote under date of January 2d, 1914. This Company used

Nonpareil Insulating Brick

on their tank furnaces. The results they obtained are set forth in this extract from their letter:

"We have used your Nonpareil Insulating Brick on the nose of our Green Furnace since Nov. 10th, 1913, to take the place of fire boards to keep the heat off the workmen and we liked it so well that we equipped our Amber tank the same way two weeks ago, and are now equipping our Flint tank; and want to say to you that we are going to use your brick at our Swedesboro plant also, for we consider them the best thing we have ever come across to keep the heat confined where we want it, i.e. in the furnace, and be able to work on the outside with comfort in the hottest weather."

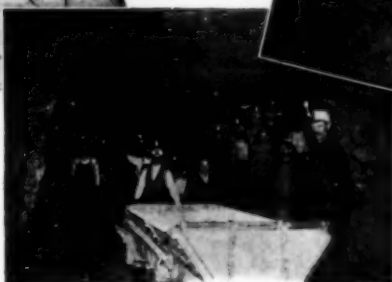
Write for Free Sample and Full Information today

Armstrong Cork & Insulation Co., 156 24th St., Pittsburgh, Pa.

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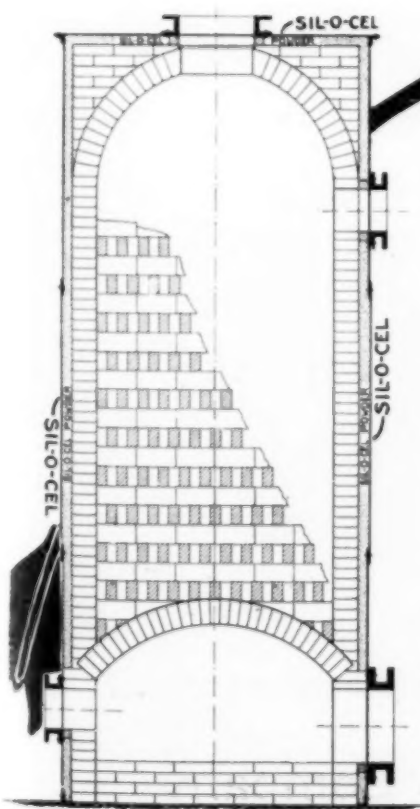


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"The Brick with a Reputation"

THE ASHLAND FIRE BRICK CO., Ashland, Ky.



Typical construction showing use of powdered Sil-O-Cel between lining and shell.

SIL-O-CEL

Nature's Non Conductor

—the most effective material known to the industrial world for the insulation of gas generators and other high temperature equipment. It is used in powdered form between the brick lining and the steel shell. It absolutely conserves the heat, prevents rupture, bulging and shearing of the shell, because the heat cannot escape through the fire brick lining and overheat the exterior. This means maximum efficiency and minimum depreciation of your plant. Sil-O-Cel will not melt—will not flux or settle—it is permanent.

Sil-O-Cel is used for insulating:

Gas Generators,	Carbureters,	Ovens,
For water, oil,	Retorts,	Furnaces,
and producer gas,	Lime Kilns,	Driers,
Superheaters,	Stoves,	Boilers, etc.

Samples for testing and a descriptive booklet sent to those interested. Sign the coupon and mail today.

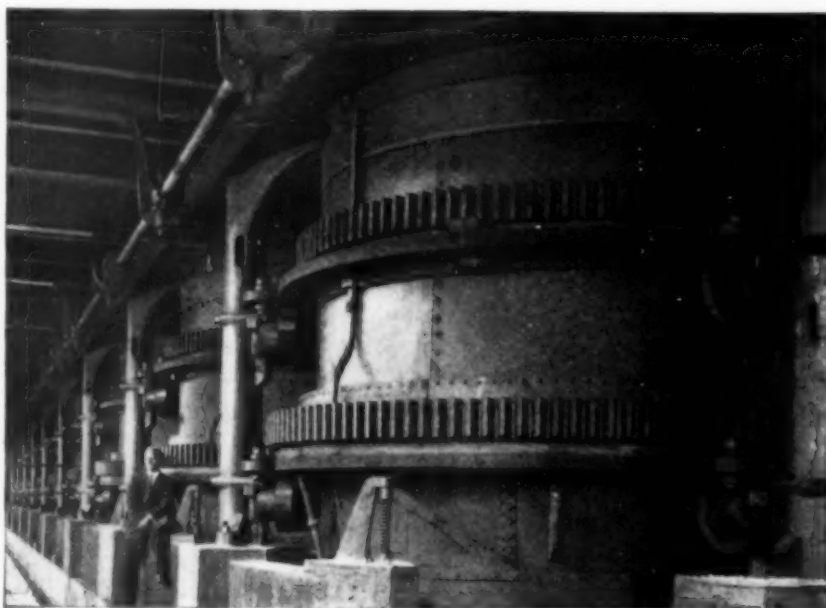
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Chapman Rotary Gas Producers



Half of Producer installation at Bethlehem Steel Company, South Bethlehem, Pa.

Automatic Distribution of Fuel—
Automatic Agitation of Fire Bed—
and Automatic Removal of Ash

Are Essential to

*A Low Labor Cost and
Rich and Uniform Gas.*

The CHAPMAN is the only Producer on the market embodying all three of these features.

Three repeat orders for Chapman Producers have been received from the Bethlehem Steel Company. There are now eighteen 10' Chapman Producers in operation at this plant.

*Write us about your Gas
Producer problems. We
may help you solve them.*

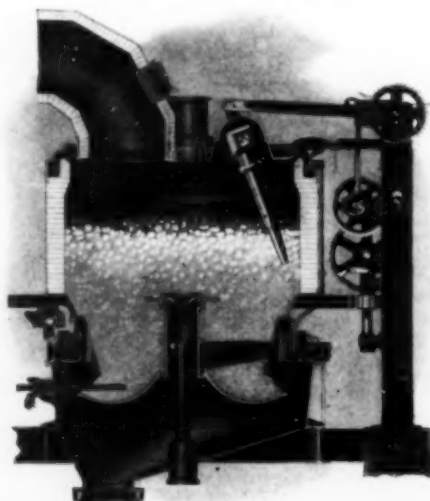
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The Hughes Mechanical Gas Producer

700 Machines in Operation



There are reasons for the extensive adoption of the Hughes Producer.

REASON No. 6

It does more than it is guaranteed to do.

It is different from the others. Let us explain it to you more in detail

New Catalog just issued. May we send you a copy?

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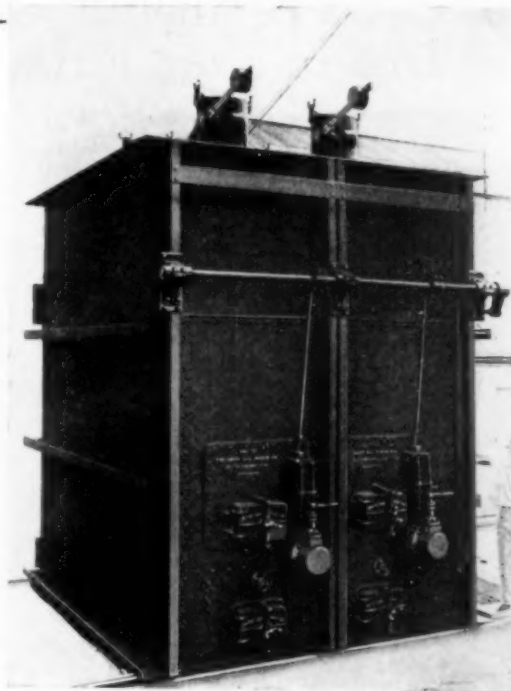
Smith System Service

The Mechanically Operated Smith Sectional Gas Producer shown herewith has replaced natural gas in a plant requiring exceedingly accurate temperature control. Pyrometer readings show that the maximum temperature variation when using Smith Producer Gas is less than half of that with natural gas. The temperatures required are approximately 2100 degrees F.

The increased output of a more uniform product will shortly return to the owners the original cost of the plant.

Heretofore natural gas was considered the ideal fuel. That was before the days of Smith System Service.

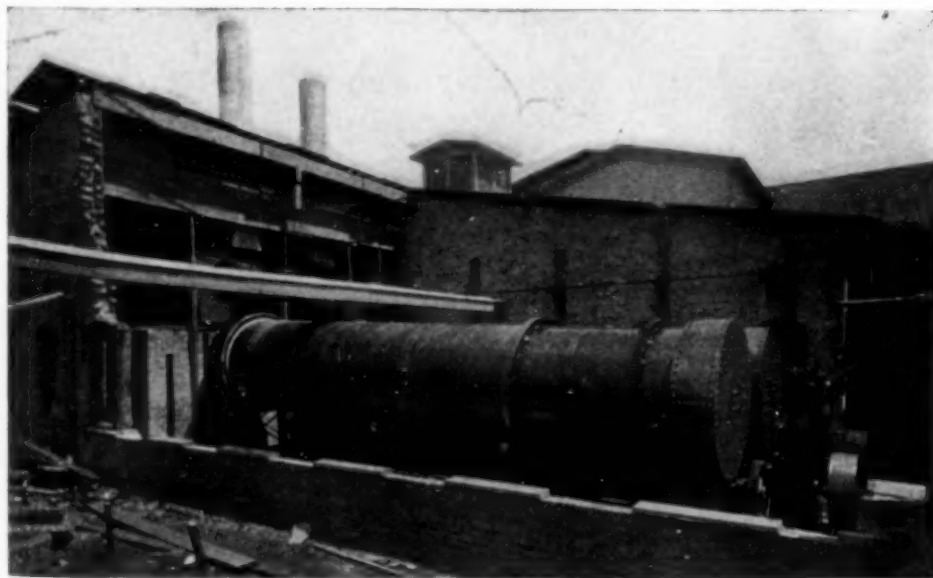
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"Internally fired" are the only type of indirect heat dryer with a high thermal efficiency. The products of combustion do not come in contact with the material being dried and thus there is no discoloration of the finished material.

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30%-40% saved over hand firing

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and quality that will meet any requirements in the metallurgical and chemical fields.

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Powdered Coal, Oil and Gas Burning Equipment, Furnaces, Core and Mould Drying Ovens, etc.

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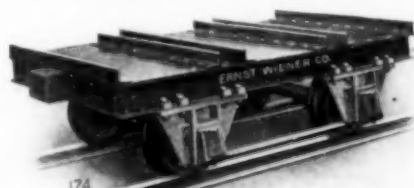
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Special Industrial Cars

To your or our own designs



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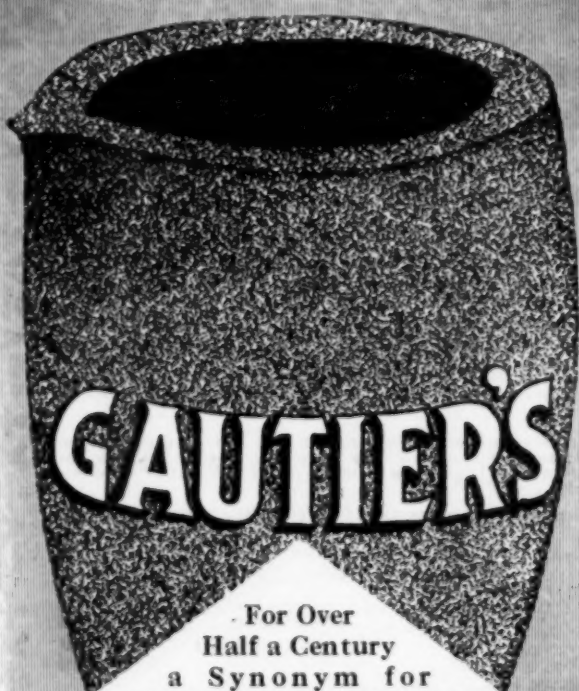
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are used where results are considered as more important than time lost and material wasted. May we send you "Crucibles: Their Care and Use"? Please mention No. 243-A.

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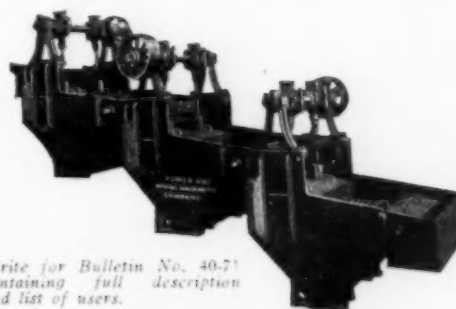
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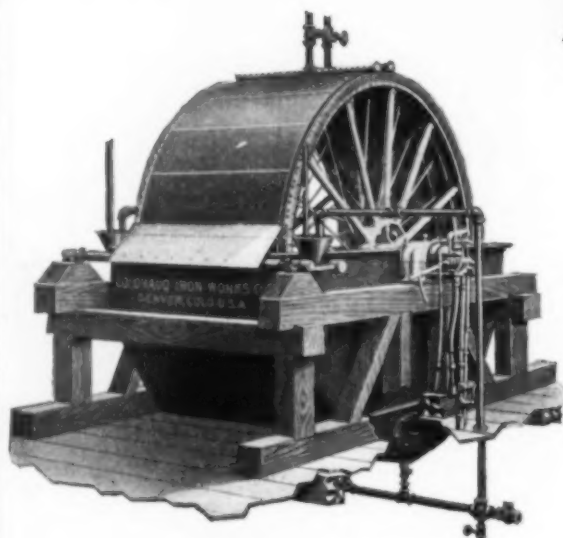
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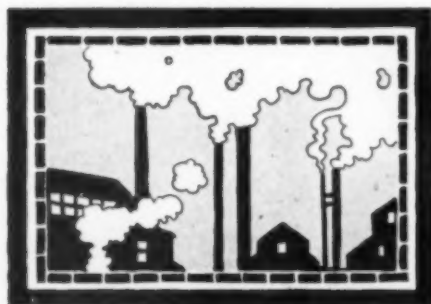
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is an ENGINEERING Metal

Guaranteed
99.86%
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AN engineering metal is a metal that no purchasing agent would buy of his own volition—a metal that competes in price only when certain *quality* factors are admitted to the equation.

In purchasing Vismera Pure Iron PLATES for tanks, vats, stacks, pipe lines, penstocks, tank cars, boats, etc., the extra cost of the raw material would probably add scarcely 5% to the cost of the finished work.

Yet that 5% may multiply the life of the structure or receptacle because Vismera Pure Iron is so free from internal enemies that external enemies find no place for lodgment. The same quality factor—the length-of-life value of Vismera Pure Iron—must be admitted to the cost equation when buying raw materials for SHEET METAL work of all kinds including roofing, siding, piping, light tanks, etc.

Vismera Pure Iron is sold on the basis of a guaranteed analysis, and is made by a process and from materials sufficiently uniform to make a guarantee commercially possible.

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(Two points better than our guarantee)

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CopperNone
Aluminum OxideNone
Carbon040
Phosphorus004
Sulphur020
Manganese040
Hydrogen	......001

Oxygen	......009
Nitrogen	......004
Total Impurities118
Total Content	100.000
Total Impurities118
Total Purity	99.882

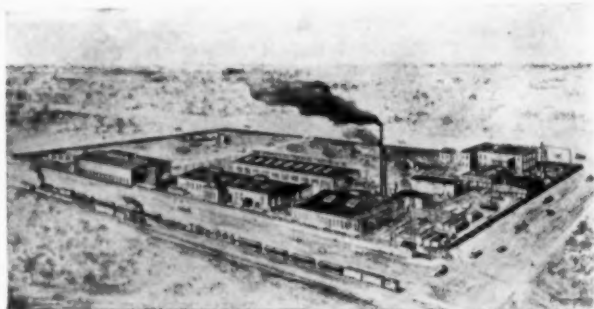
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The Art of making steel tanks Plant Equipment 11

Imagine a ten-acre enclosure nearly square, nearly half covered with buildings, the other half "tank yards" for riveting, calking, painting and storing.

Then picture a network of standard gauge railway tracks inside our yard connecting with Chicago's famous Outer Belt railway system.

Let your eye set down into the picture numerous electric cranes for unloading raw materials and loading finished tanks.

And note, too, a network of high-pressure pipe carrying compressed air to a multitude of taps, each with its hose coupling ready to connect the right pneumatic tool with an air supply that aggregates thousands of cubic feet per minute.

Then take a tour through some of the buildings and see spacing tables of Wm. Graver's own invention that give the rivet hole punching operation great speed with accuracy; motor driven bending rolls, riveters, flanging machines and other heavy equipment.

Ask to see the machine shop, tool-tempering room, forge shop. Step into the pump house where the big centrifugal pumps keep three 15,000-gallon water storage tanks filled with water—warmed in winter. Note carefully that this \$10,000 pumping plant is maintained solely for the purpose of filling, inspecting and testing every Graver tank before it's shipped.

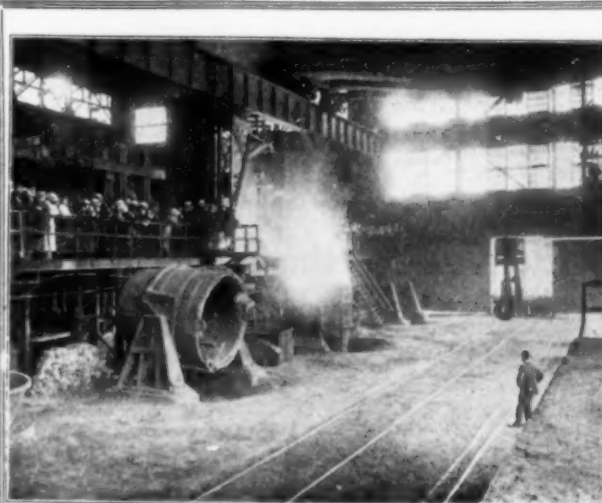
Then, after your tour of the yards and shops is completed, step into one of the largest and best equipped engineering departments in any tank-building plant in the world.

When you leave, you will have gained a superficial view of the Wm. Graver Tank Works—a plant that is ready for anything and big enough and capable enough to take care of any order, however large.

Not only is there an "art" in making steel tanks, but there must be the equipment and the capital and the men back of the art.

All these are at your service.

WM. GRAVER TANK WORKS
East Chicago, Indiana.



The Fight for Durability

Chapter I.

Much has been written regarding the production of pure iron in the open hearth furnace. Few have been informed of the sleepless nights and nerve racking days spent by our Open Hearth Dept. in fighting down the impurities usually found in steel.

To accidentally burn steel in the open hearth furnace was crime; to do so on purpose, the act of a mad man. Yet this step had to be taken before pure iron was a reality.

We could not point with pride to the wild heats poured all over the floor of the open hearth to avoid the dreaded salamander in the ladle pit. No crepe was displayed when fifty-ton salamanders were gently buried in the ground instead of being rolled into sheets. No murmur of protest came from the lips of those whose clothes were burned in holes to the lacerated skin in an effort to keep the heat from freezing in the ladle. No retreat was sounded when the extra intense heat required to burn out the last traces of impurities caused the furnace roofs to drop and cave in, the ladle lining to be replaced four to five times as often as required in producing steel.

ARMCO IRON Resists Rust

We realized no big undertaking came easily; our task was to produce pure iron in the open hearth furnace, and we did it. May we not be justly proud of the unequalled durability of Armco-American Ingot Iron?

The American Rolling Mill Co.



The trade mark ARMCO carries the assurance that iron bearing that mark is manufactured by The American Rolling Mill Company with the skill, intelligence and fidelity associated with its products, and hence can be depended upon to possess in the highest degree the merit claimed for it.

Licensed Manufacturers under Patents granted to The International Metal Products Company.

Armco-American Ingot Iron, Black and Galvanized Sheets, Roofing, Pipe, Gutter, Metal Lath and Terne Plate.

Middletown, Ohio

District Sales Offices at Chicago, Pittsburgh, Detroit, Cleveland, New York, St. Louis and Cincinnati.

OPERATORS

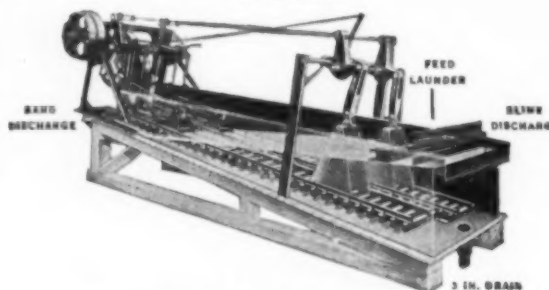
who are interested in

**Washing
Dewatering
Mixing**

should study these Standard Machines.

The Dorr Washer or Classifier

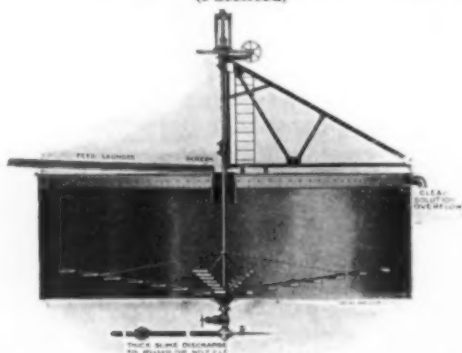
(Patented)



Has features of special value for removing sand from ground products and washing same; counter current leaching of granular materials, etc. Great flexibility of products produced, extreme low cost of operation and upkeep.

The Dorr Dewater or Thickener

(Patented)



Fine material suspended in any quantity of liquid can be fed to this machine, a clear overflow obtained and a thick pulp drawn continuously from the bottom. Continuous Countercurrent washing using these machines obviates excessive dilution as well as the use of filters.

The Dorr Mixer or Agitator

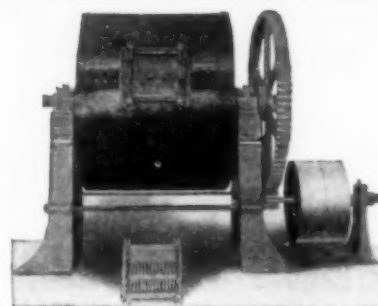
(Patented)



Will keep all the pulp in suspension all the time. Absolute reliability, avoiding the use of centrifugal pumps or other wearing parts. Operating costs lower than those of any other agitator. All of the above machines can be built acid proof. Write now for our Catalogue and full engineering data bearing on your problem.

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Codes: Bedford-McNeill and Western Union.

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Paul O. Abbé Pebble Mills are built in twelve sizes, from 25 lbs. to 4000 lbs. charging capacity. For eighteen years I have given my personal supervision to the manufacture of all classes of crushing and grinding machinery.

Send for illustrated pamphlet showing the result of this specialization.

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Utilization of Waste Products**RICKETTS & BANKS**

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New York

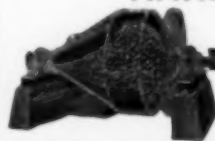
Examinations of Properties. Advice as to their development and operation. Complete testing plant to determine best method of ore treatment. Fully equipped research and experimental laboratories. Assays and Analyses of Ores, Metals, Fuels, Waters, etc., etc.

Special facilities for making leaching tests of copper and other ores.

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FOR
ECONOMICAL FINE
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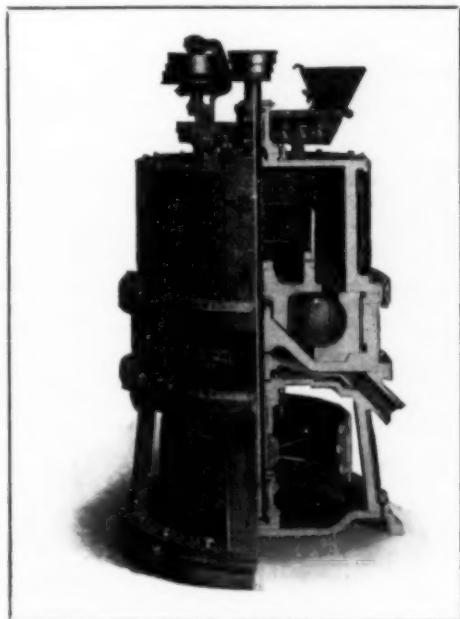
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50 CHURCH ST.
NEW YORK



**BACON & FARREL
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ROLLS-CRUSHERS**
EARLE C. BACON, ENGINEER
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THE FULLER-LEHIGH PULVERIZER MILL

The Most Economical Mill for Pulverizing Various Refractory Materials



AS FOR EXAMPLE:

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Asbestos Rock
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Barytes
Bauxite
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Bone Black
Carbon
Cement Rock
Cement Clinker
Chalk
Charcoal
Chrome Ore
Clay
Coal
Coke
Copper Ore
Dolomite
Feldspar

Fire Clay
Fluor Spar
Foundry Facing
Fullers Earth
Glass
Gold Quartz
Graphite
Gypsum
Hydrated Lime
Iron Ore
Kaolin
Lava
Lime
Limestone
Lithopone
Magnesite
Marble
Ochre

Ores
Oyster Shells
Paint
Phosphate Rock
Plaster
Portland Cement
Puddler's Slag
Quartz
Shells
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Slag
Slate
Talc
Tripoli
Tufa
Umber
Vanadium Ore
Whiting

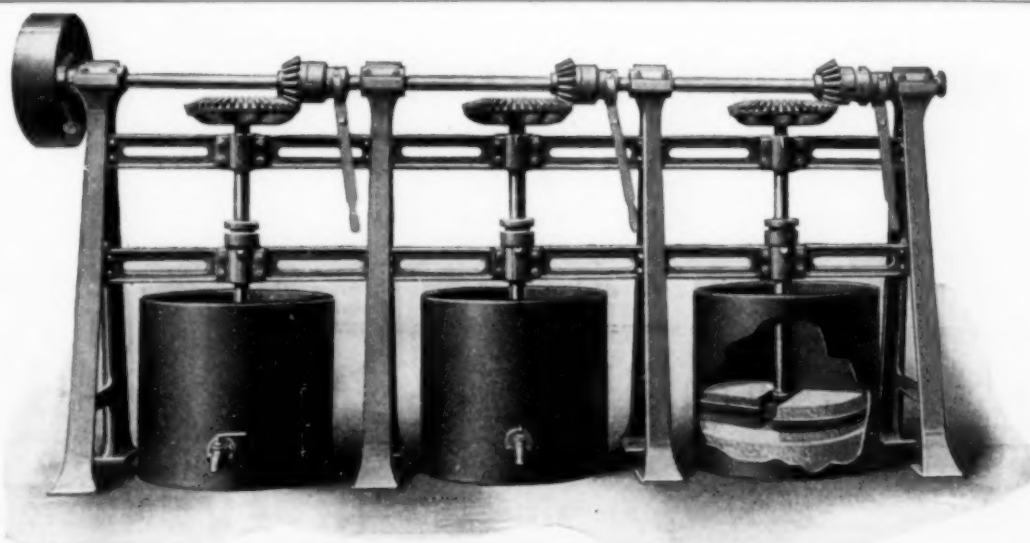
If interested in heating furnaces with PULVERIZED COAL, investigate our Pulverized Coal Equipment. Crush your coal with our LEHIGH CRUSHING ROLLS. Dry your coal with our INDIRECT FIRED ROTARY DRYERS. Pulverize your coal with our FULLER-LEHIGH PULVERIZER MILLS. We will be pleased to send full information and catalogue upon request.

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BUILT IN ALL SIZES FROM 12 INCHES TO 8 FEET IN DIAMETER

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Also all kinds of Furnace Ironwork.

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Your Fine Ores, Concentrates, Fluedust can be cheaply and successfully sintered by the
**DWIGHT & LLOYD CONTINUOUS SYSTEM
 OF BLAST ROASTING**

(Patented in United States and Foreign Countries)

SIMPLE—EFFICIENT—LOW FIRST COST

Large installations are in continuous daily operation in many smelting plants of our Licensees in United States, Canada, Mexico, Australia and Europe. For particulars and estimates address:

DWIGHT & LLOYD SINTERING COMPANY, Inc., 29 Broadway, New York

(SUCCESSOR TO DWIGHT & LLOYD METALLURGICAL CO.)

CABLE ADDRESS: SINTERER—NEW YORK

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Most Economical Grinding

FROM RESULTS OBTAINED BY OUR CUSTOMERS WE ESTIMATE THE CAPACITY, AS FOLLOWS, OF THE

MAXECON MILL

Limestone	4 tons per hour to 95%	100 mesh
Florida Pebble	7 tons per hour to 90%	60 mesh
Bauxite	4 tons per hour to 95%	100 mesh
Hardest Ores	5 tons per hour to 90%	50 mesh
Coal	4 tons per hour to 95%	100 mesh
Silica	2 tons per hour to 95%	200 mesh
Cement Clinker.....	10-12 bbls. per hour to 98%	100 mesh

With Under 25 H. P. Minimum Wear and Repairs

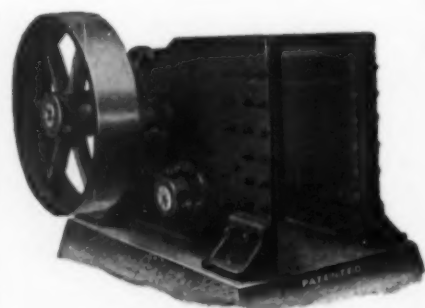
Used as a Standard Grinder by the United States Steel Corporation, Aluminum Company of America, Pennsylvania Salt Manufacturing Company, Virginia Carolina Chemical Company and practically universally in the chemical fertilizer factories of the United States and Europe. Send for Bulletin 36.

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BALL MILLS EXCELSIOR MILLS
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 FORGINGS OF ALL QUALITIES OF STEEL
 SPECIAL MACHINERY OF ALL CLASSES

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CRUSHERS

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Thirty Years of Practical Experience has taught us that no one machine is adapted to all purposes. Customers expect correctly designed machines for their special work. Our large line enables one to select properly. It consists of:

CRUSHERS—For coarse, medium and fine work on hard or soft rock. Jaw, Rotary and Hammer design.

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Sampling Crushers, Rolls, Grinders and Screens. Send for Catalogue.

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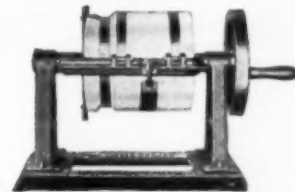
NEW YORK CHICAGO

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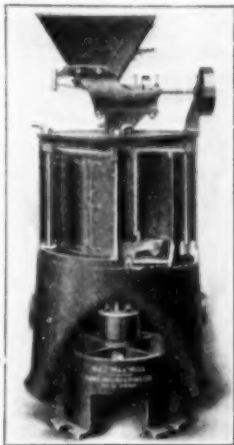
VICTORIA, B. C. LONDON ENG.

PULVERIZING PROBLEMS EFFICIENTLY SOLVED

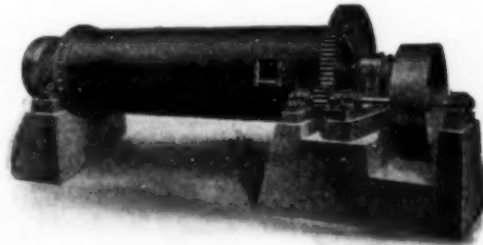
We have twenty-five styles and fifty-nine sizes with over 100 machines in stock to select from, also a completely equipped testing laboratory for your use.



LABORATORY PEBBLE MILL
(Jar Mill)
Built in a Large Number of
Sizes.



IMPROVED "MAX" MILL
(Patented)
for Grinding Nitre Cake,
Arsenate of Lead, Salts, Lime,
Sugar, Crucibles



ABBÉ TUBE MILL.
Trunnion Type (Patented)
for Pulverizing Ores, Cement, Limestone, Coal, etc.

Our laboratory service offers facilities for expert analyzing of given conditions, and the best means for economical and efficient execution of the class of work which comes under our field of endeavor.

Get the benefit of our
34 years' experience.

We also build Disintegrators, Rotary Cutters, Vacuum Pumps,
Pressure Blowers, Vacuum Heating Pumps, Bolting Cloth.

Send for Catalogs.

ABBÉ ENGINEERING CO.
218-220 BROADWAY, NEW YORK

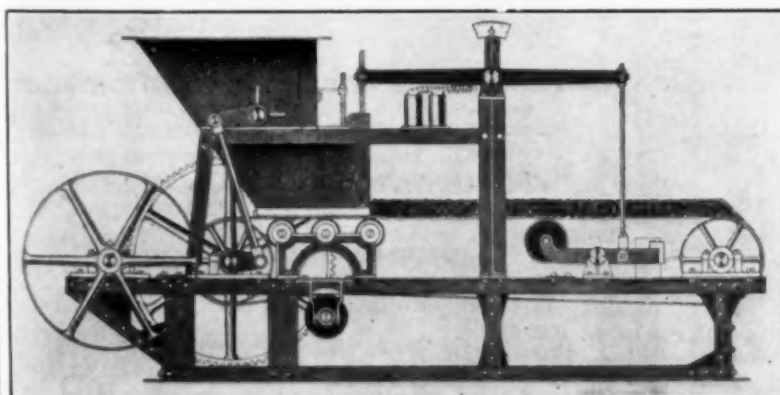
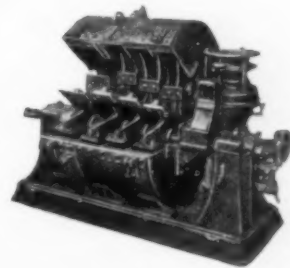
BURN PULVERIZED COAL BY THE AERO SYSTEM

BECAUSE

1. It gets every available B.T.U. out of the coal.
2. Makes available slack coal and screenings at a fraction of the cost of mine run and lump coal and oil.
3. Eliminates the danger of fire or explosion from fuel in storage.
4. Both temperature and quality of flame accurately controllable at all times.
5. Construction prevents clogging by obstructions and guarantees continuous dependable action.
6. Perfect combustion is effected—No soot—no smoke, no free oxygen, no CO.

Shall We Send "Real Evidence"?

AERO PULVERIZER CO., 61 Broadway, NEW YORK



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The "Poidometer"

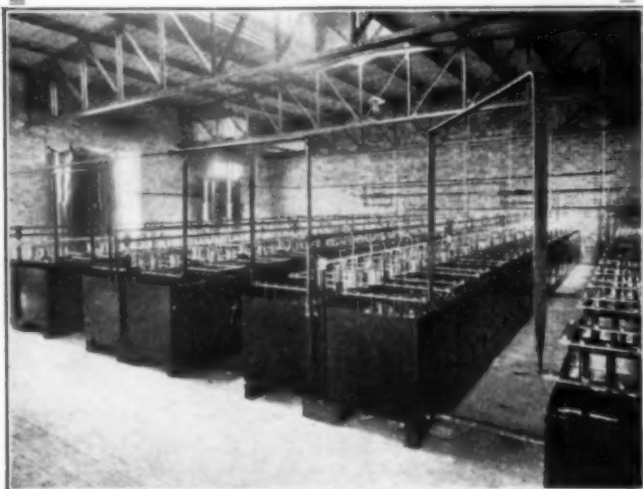
eliminates the "Human Element"

- eliminates the wages of the "human element"
 - eliminates errors due to the "human element"
 - assures accurate compounding and mixing of materials.
- Full data on request.

**The Schaffer Engineering
and Equipment Co.**

Tiffin, Ohio, U. S. A.

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OXYGEN or HYDROGEN
 for Welding, Cutting, or
 Chemical Work
 Why not make your own?



BURDETT Apparatus

gives chemically pure Gas at a fraction of the cost of cylinder gas

With the *Burdett System* a supply of 99½ per cent. pure gas is always available. No hold-ups by failure to ship, by delayed freight, by neglect in ordering.

Burdett Oxygen or Hydrogen is far purer than cylinder gas, gives far more satisfactory results, costs only about one-half as much. Why not use it?

Burdett Service means the study of your particular conditions, the supplying of apparatus exactly suited and *co-operation* in maintaining the highest efficiency.

Our "Bulletin 6" describes fully this dependable, economical system.

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New York
 54 Church Street

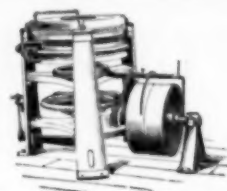
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8557

GRINDING MILLS



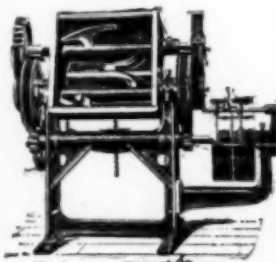
Improved Lead and Paste Mill

Disintegrators, Dryers
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Plans and Estimates for
SPECIAL MACHINERY
 Promptly Furnished

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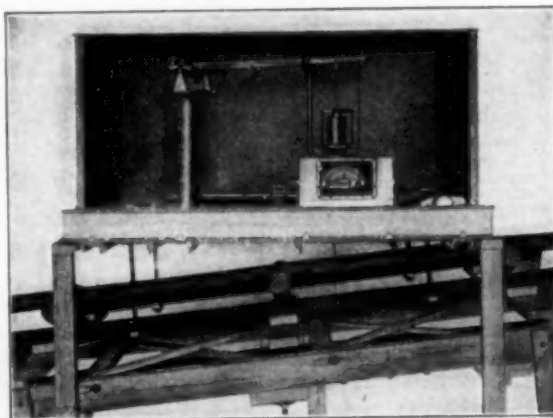


Giant Kneading and Mixing Machine

Write for Catalog
 showing complete
 line of Mills and

**MIXING
 MACHINES**

BUILT—not assembled



The Merrick Conveyor Weightometer

when installed on your Belt, Bucket or Pan Conveyors will automatically and continuously record, in any unit desired, the exact weight of material transported, with a guaranteed accuracy

WITHIN ONE PER CENT.

Write for our descriptive Bulletin. It's interesting reading.

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 223 Main Avenue, Passaic, N. J.



I.O.C. Single Unit Generator

There is a saving that means *in- creased* Profits

in making Oxygen and Hydrogen on your own premises instead of buying gas in cylinders—if you install an

I.O.C.
SYSTEM
Plant

With no upkeep expense, automatic, simple and safe, the I. O. C. System offers the cheapest and most approved method of producing these gases (of the purest quality) for all welding and cutting purposes.

Constructed on the unit part system, your I. O. C. plant need be no larger to start with than your present needs. Additional units may be employed as circumstances warrant.

Send for data showing results secured both in this country and abroad.

International Oxygen Company

General Sales Offices, 115 Broadway, NEW YORK

Works NEWARK, N. J.

Pittsburgh, Pa., Park Bldg.

Paris, France, 40 Rue Lafitte

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(Told by Users)

Do mistakes in proportioning or weighing raw materials threaten the uniformly high quality of your product? Does overweight or underweight in packing make trouble and expense for you? Read what automatic weighing has accomplished—told by the men it serves.

SHIP US ANOTHER

"This is the most satisfactory automatic weighing machine we have ever used. We want you to ship us another machine exactly like the first one No. 1514, just as quickly as possible and advise us how soon your expert can be with us to install same."

HIGH CAPACITY AND ACCURACY

"We think putting in a second machine of your make expresses better than words our appreciation of its efficiency both as to correctness of weights and capacity."

We make special types of machinery to meet the needs of different industries.

WRITE FOR COMPLETE DESCRIPTIVE BULLETINS.

AUTOMATIC WEIGHING MACHINE COMPANY

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For Oxy-Acetylene Welding & Cutting

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PREST-O-LITE

THE employment of Prest-O-Lite for all Oxy-Acetylene welding and cutting operations increases the efficiency and money-saving possibilities of this process for every factory and repair shop.

Prest-O-Lite means greater **convenience, simplicity, portability, economy** and **utility**, no matter whose Oxy-Acetylene apparatus you employ.

The quality of the work done is higher, because Prest-O-Lite furnishes Acetylene which is absolutely free from impurities and moisture which weaken welded joints and handicap the operator.

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Because of its unique position as the world's largest producers, this company has facilities for furnishing the highest grade, purified and dried Acetylene in any quantities to users everywhere.

Prest-O-Lite Acetylene Service furnishes the highest grade of dissolved Acetylene in portable cylinders, used as conveniently as you use cylinders of oxygen. Saves the large initial outlay and heavy depreciation, trouble and inconvenience of making crude acetylene in carbide generators. Besides, Prest-O-Lite dissolved acetylene is perfectly dried, cleaned and purified—makes better welds and is cheaper to use.

We can furnish a thoroughly high-grade welding apparatus for \$60. Special equipment for cutting operations supplied at extra cost.

No matter what use you make of acetylene, no matter whose apparatus you employ, Prest-O-Lite Acetylene Service means quality, convenience, safety, and economy.

Interesting data on request. Send for it.

The Prest - O - Lite Co., Inc.

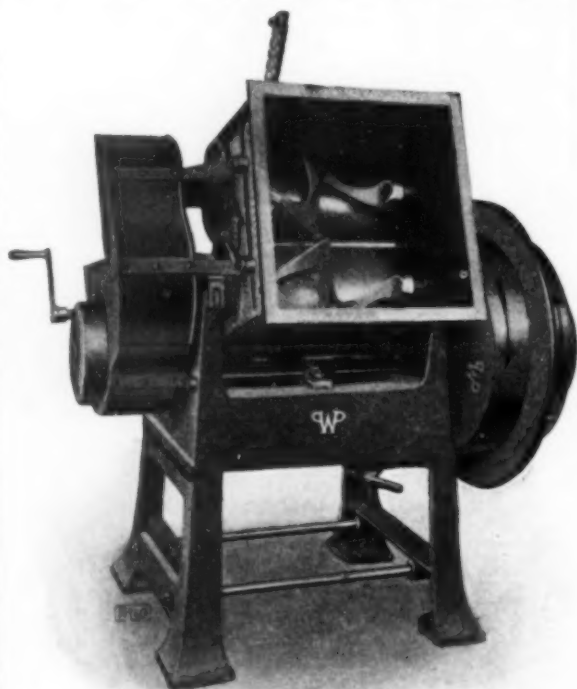
819 Speedway
Indianapolis, Ind.

55 Direct Factory Branches
and Charging Plants in Principal Industrial Centers



Operator Welding joint in manufacture of all-steel kitchen cabinet.

We Are Specialists in Kneading and Mixing Machinery



One of the types of W. & P. "UNIVERSAL" MIXERS tilted to show the interior.

There are a great many different standard designs of W. & P. "UNIVERSAL" MIXERS, some of which will mix **YOUR** material efficiently.

The following are some of the materials in the manufacture of which our machines are doing good service:

Acumulator Mass,	Chewing Gum,
Aniline,	Gutta Percha,
Blasting Powders,	Indigo, Doughs and Solutions,
Celluloid,	Insulating Material,
Chocolate,	Linoleum,
Colors,	Macaroni,
Cordite,	Paper Cellulose,
Crucible Paste,	Paper Pulp,
Dog Biscuits,	Paint,
Doughs of every description,	Putty,
Electrode Mass,	Rubber Solutions,
Explosives,	Artificial Silk.

We also manufacture:

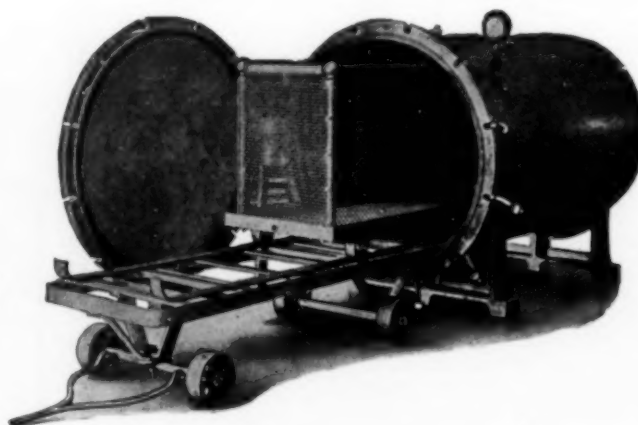
Automatic Weighing Scales,	Rubber Washers,
Vacuum Kneaders,	Masticators and
Filter Presses,	Solution Making Machines.

Werner & Pfleiderer Co., Inc.

Factory and Main Office: Saginaw, Mich.

New York Office: Tribune Bldg. Philadelphia Office: Drexel Bldg.
San Francisco Office: Pacific Bldg.

Metallurgical and Chemical Machinery and Apparatus of any kind



Metal work in steel, iron, bronze, monel metal, brass, lead, block tin or zinc, is our specialty. Tanks of all kinds, mixers, agitators, impregnating and drying apparatus, stills, boilers and vacuum and pressure pumps. Submit your blueprints and specifications for estimates. Work treated confidentially.

L. O. KOVEN & BROTHER

50 Cliff Street, New York

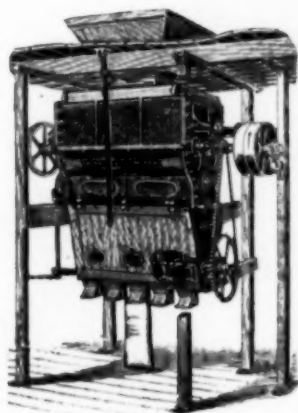
WORKS: JERSEY CITY

CABLE ADDRESS: "KOVENLO"

D

Number Seven

WHAT USERS SAY
ABOUT
Broughton Mixers



Style A Mixer

For use where product tends to bridge and not flow freely. Agitator keeps mass in motion and delivers evenly to chutes or sacks.

**Ten Years' Continuous Use
Told in This Letter**

"We have been using the *Broughton Mixer* for ten years, and it has given entire satisfaction all this time. In our opinion it is the best mixer we know of. Parts which naturally wear out by continuous use are easily adjusted. The very principle of your mixer is consistent with turning out a perfectly mixed product." *Granite Wall Plaster Co., Lebanon, Pa.*

Adapted to any dry mixing work
Such as chemicals and cements

Note—This series of advertisements will show how Broughton Mixers are giving satisfaction in all fields. Watch for each one. Send for catalog if interested at present time in efficient mixing.

W. D. DUNNING
SYRACUSE, N. Y.

6935

D



Has caused a serious interruption of industrial processes by the sudden cessation of chemical supplies. Now is the time to increase American production—to add to equipment. The demand is imperative! But difficulties await the manufacturer who purchases second-rate apparatus.

ADOPT THE DOPP

**SEAMLESS
Jacketed Kettles, Mixers,
Vacuum Pans**

and you adopt equipment that 57 years of actual use, experience and service have proved reliable in every particular.



If you need

such equipment for either experimental or manufacturing purposes, you will find important information in our Catalog V—Section 1.

Send the coupon.

Sowers Mfg. Co.

1302 Niagara Street
Buffalo, N. Y.

The quick easy,
convenient way
to get the
data, send
it now

Sowers Mfg. Co., 1302 Niagara St., Buffalo, N. Y.
Kindly send me your Catalog V, Section 1.

Name.....

41303

M.C.F.



Vastly Superior to the Rotary Type for Blast Furnaces, Cupolas, Forge Shop Work, Smelting and Refining Plants, Sintering Plants, Glass Blowing and all sorts of Metallurgical and Industrial Chemical Plants.

Sirocco
TRADE MARK

When you install a Sirocco fan-type, direct-connected blower instead of a blower of the rotary type, here's what you effect—a saving of two-thirds in first cost—a saving of one-half in operating power and a saving of two-thirds in floor space.

ANOTHER ADVANTAGE—The power required to drive a Sirocco fan blower is only proportional to the volume discharged, whereas with the positive or rotary type the power remains at maximum whether the blast is full or half or entirely closed off.

Write for more complete analysis and description. Ask for Bulletin No. 8025.

AMERICAN BLOWER COMPANY

DETROIT MICHIGAN U.S.A.

Canadian Sirocco Company, Ltd., Windsor, Ont., Manufacturers for Canada.

Type "P" Special Pressure Blowers



Observe
the
Length
of
Bearings

"Buffalo" Acid Fans



Let us aid you to select the fan best suited for the work which you wish to do. We are equipped to construct fans or exhausters from copper, aluminum, monel metal, cast iron, lead or any metal or combination of metals most suitable. We feature special work of this character and through our years of experience in the field are equipped to turn out apparatus possessing the efficiency and durability essential to satisfactory service.

Buffalo Forge Co., Buffalo, N. Y.

Manufacturers:—Spray Nozzles, Air Washers, Heating, Ventilating and Drying Apparatus. Branch Offices in all Principal Cities.



Vulcanized Fibre Valves

Here is an actual case. An American Vulcanized Fibre Valve was taken from a boiler feed water pump in perfect condition after 3 years' service pumping water at 212° F. against a pressure of 150 lbs. per square inch.

American Vulcanized Fibre

is specially adapted to uses in the chemical and metallurgical processes where neither rubber or leather will stand the service. Tough, flexible, of great value for thermal and electrical insulation, it is widely used for insulating electrochemical apparatus, and for valves, gaskets and packing for high pressure pipe lines carrying air, water or gas. Hot or cold water service.

WRITE FOR FULL DATA.

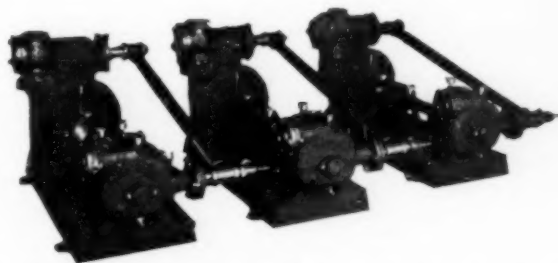
American Vulcanized Fibre Co.

Wilmington, Del.

Boston, 12 Pearl St.

9461

A VACUUM PUMP FOR AIR OR GAS CONTAINING HOT OR DIRTY LIQUIDS



Three Nash Hydro-Turbines in combination with Gould Centrifugals,
a repeat order from one of the largest paper mills in the United States.

This outfit consists of a Nash Hydro-Turbine Vacuum Pump, combined with a centrifugal water pump. The Hydro-Turbine, with its large capacity, maintains the vacuum, and keeps the centrifugal free from air.

The liquid is all taken care of in the centrifugal, which will stand up satisfactorily even under the action of abrasive material, and may

be cheaply replaced if it finally wears out. The liquid may be delivered against a high head, without back pressure being transferred to the air pump.

This combination affords the most reliable and efficient means of handling air containing a large percentage of water, as the air and water are taken care of separately in pumps specially designed for each material.

NASH ENGINEERING CO., South Norwalk, Conn., U. S. A.

Morse "Rarefied" Collectors



"This Reduction in Horse Power is a Great Thing

To-day we are operating the entire department with two 10's and one 5, making a total of **25 Horse Power**, and before the installation of these little collectors we used **45 Horse Power** to do the same work."

The Sterling Grinding Wheel Co.,
Tiffin, Ohio, Oct. 26, 1914. George Tillotson, Mgr.

The Morse Rarefied Dust Collector

is located between the source of dust supply and the fan so that the air is not forced into the collector but is drawn through it. By this arrangement the dust is separated from air before passing through fan—there is no cutting out of fan—no grinding of dust on collector.



Write for
Catalog

The Knickerbocker Co., Jackson, Michigan

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You may have your subscription to Metallurgical and Chemical Engineering extended according to a co-operative plan which we occasionally offer to our readers.

Among your business associates and acquaintances there undoubtedly are a number of men who would find a personal copy of this journal of value in their work. Our experience shows that those to whom the value of Metallurgical and Chemical Engineering has been explained by a reader of this paper consider the introduction as a favor.

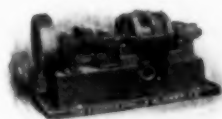
As we desire to recognize co-operation of this sort, we offer to extend any reader's subscription for a period of three months for each new subscription secured by him.

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METALLURGICAL AND CHEMICAL ENGINEERING

239 WEST 39th STREET
NEW YORK



Connersville Valveless Pump

Vacuum Heating

Cyanide and concentrating mills generally require heating for a considerable part of the year. This can be most economically done by the vacuum system by the CONNERSVILLE Valveless Rotary Pump. The same system may be employed for efficiently heating solutions. This Pump maintains vacuum up to 10 inches, at the same time returning condensation to low pressure boiler. It has since 1908 been widely used for vacuum heating service in modern office buildings, hotels, etc., throughout the country. Bulletin 12AC explains fully and contains diagrams of value. Ask for it.

Vacuum Filtration

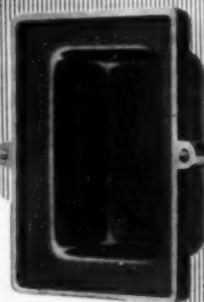
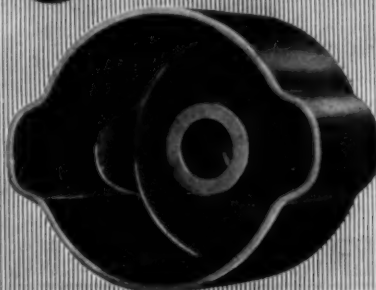
The application of the CONNERSVILLE Valveless Rotary Pump to vacuum filtration has been attended with marked success. The Pump is of modern design and possesses important advantages placing it in a class by itself. Rotary motion only, simplicity of construction, reliable operation, are noteworthy features. Built for maintaining 26 inches vacuum (sea level). Special Pumps can be furnished for 28 inches vacuum. Cannot be damaged by variation in the proportion of air and liquid handled.

Flotation Blowers

The success of the flotation process is largely dependent on securing a reliable and efficient positive pressure blower. CONNERSVILLE Blowers are preeminently successful in this work and are built for continuous service against pressures up to 10 lbs. They are short, massive, with large bearings and shafts; also heavy bed-plate. Each Blower has six ring-oiling, Babbitt-lined bearings. The gears run in a bath of oil, fully protected by a cast iron housing. No oil or dope is required inside the Blower cylinder, since there is no contact, friction or wear.

Send for Bulletin 18AC.

The Connersville Blower Co.
Connersville, Ind.



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When the specifications call for thin parts, they mould them of

BAKELITE

BAKELITE moulded pieces are harder and stronger than hard rubber and have higher heat resistance. With this great mechanical strength is combined high dielectric strength and resistance to solvents such as alcohol, gasoline, etc.

BAKELITE moulded insulation withstands steam, oil and most chemicals.

BAKELITE has exceptional moulding qualities; the beautiful, lasting finish is not the result of polishing and buffing—that expense is saved—**BAKELITE** parts have their final finish when they come from the die.

Each **BAKELITE** piece is exactly like every other piece from the same mould. Moulding in metal inserts saves the expense of drilling, tapping and fitting.

These pieces were moulded by:
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Specialty Insulation Mfg. Co.

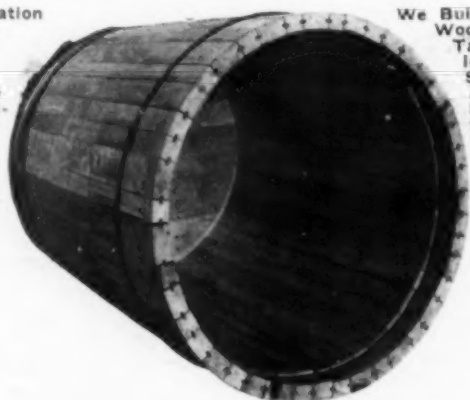
Remy Electric Company. 55-106

CENERAL

BAKELITE COMPANY

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NEW YORK

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shows
Glaze
Drum
in
Course
of Con-
struction



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Wooden
Tanks
in all
Sizes
and
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for all
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The

HAUSER-STANDER TANK

The GUARANTEED Tank

Made of Selected Genuine Louisiana Red Cypress—"The Wood Eternal." Warranted against Bulging or Leaking. Correct in Pressure Rating.

We carry in stock or will build you anything you require in the nature of a tank, still, chest, leach, drum, vat of all wood or metal lined.

Our products are sent out under the fullest guarantees. What do you require?

The Hauser-Stander Tank Co.

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CINCINNATI, OHIO

"BUFFALO" Chemical Pumps

Furnished with Single or Tight
and Loose Pulleys



Single Belted Pump with Tight and Loose Pulleys

This style pump, built in iron, lead, bronze or copper, is offered for moderate pumping heads to handle almost any chemical solution or weak acid. State metal preferred and liquid to be handled and get our price.

Buffalo Steam Pump Company

BUFFALO, N. Y.

We have made LEAD LINED IRON PIPE over Twenty Years

Be sure that you use
"Amalgamated"
Lead Lined Iron
Pipe—We are
the only makers
of that pipe in
the United States.

Also Lead Lined Iron Valves
Lead Lined Iron Stop Cocks

AND

Tin Lined Iron Pipe

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Iron Valve

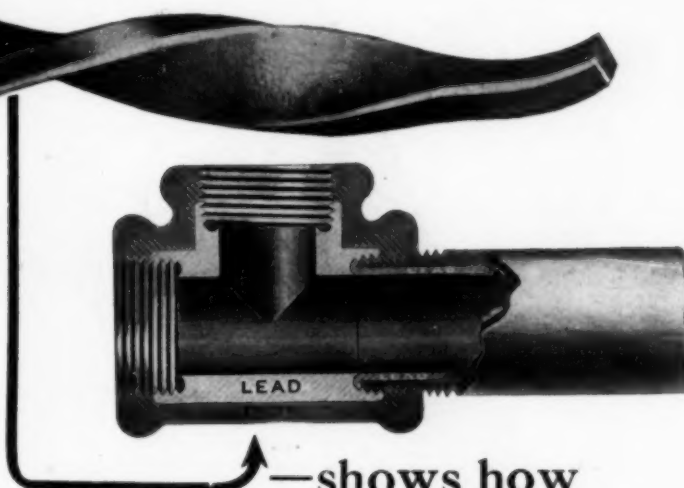
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LEAD LINED IRON PIPE CO. Wakefield, Mass.

This Torsion Test

Even the terrific shearing strain of this torsion test fails utterly to effect any sign of separation between the lead lining and iron shell of this **American-made**, acid-resisting pipe.

The mechanical strength and chemical resistivity of our special Acid Proof Valves and Pipe is a big factor in cutting equipment maintenance and obviating shut-downs in some of the biggest industrial plants on this continent. Will be glad to forward catalogue upon request.



—shows how
firmly the lead lining
is merged with the iron
shell

Lead Lined Iron Pipe and Fittings, Acid Proof Valves, Etc.

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That's the ideal for a valve metal for service in chemical manufacturing. Just study the sectional view. Note the novel and practical method of reinforcing the metal, giving a reinforced valve seat and a strong, stiff valve.



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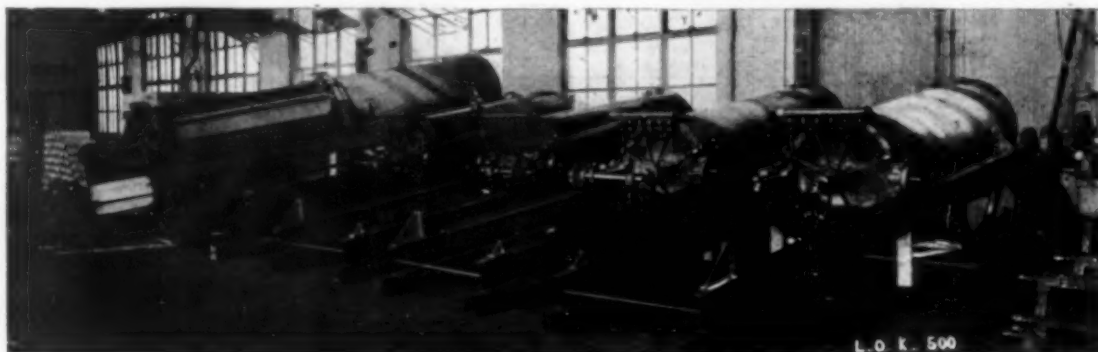
is adapted especially for controlling all grades of Sulphuric Acid, and, broadly speaking, will withstand any corrosive influence that sheet lead or lead pipe will. Write TODAY for Catalog and Prices.

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A single shipment from the erecting shop of Messrs. L. O. Koven & Brother in Jersey City, N. J.



Used in the following industries: Mines, Chemical Works, Paper Mills, Oil Refineries, Sugar Houses, Soap and Soda Works, Sewage Disposal Plants, Color Works, Water Works, Tanneries, etc.

We furnish these presses Copper, Lead and Nickel lined, and cast of Brass, Copper, Phosphor Bronze and Monel Metal. Also Jacketed to keep presses hot or cold.

For Dry Cakes, Complete Wash, Minimum Labor Costs and Continuous Hard Service, buy "THE KELLY." We are prepared to make prompt delivery from stock.

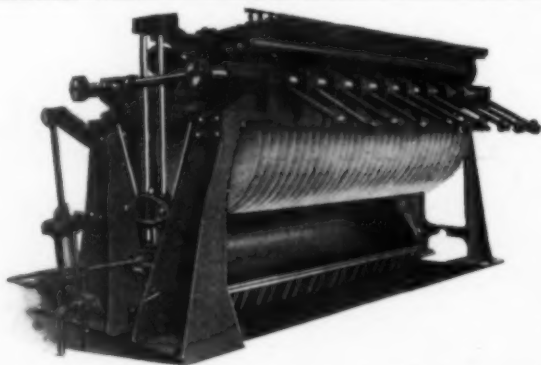
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When placing a **repeat order** with us a few days ago, the President of a very large concern said:

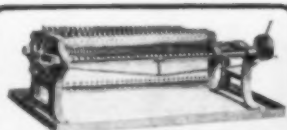
"We propose to 'Sweetlandize' our entire plant."

Nothing could be more convincing than such a statement from a man who has learned from experience that the "Sweetland Self Dumping Filter" really **Saves Money**.

"Sweetlandize" **your** plant and eliminate the troubles, leaks, inconveniences and unnecessary expenses incident to old fashioned filter presses.

Lead Lined Filters Guaranteed Acid Proof

The Sweetland Filter Press Co., 926 Singer Bldg., N. Y.



FILTER

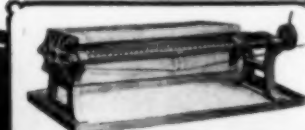
Superior in economy of operation and mechanical construction

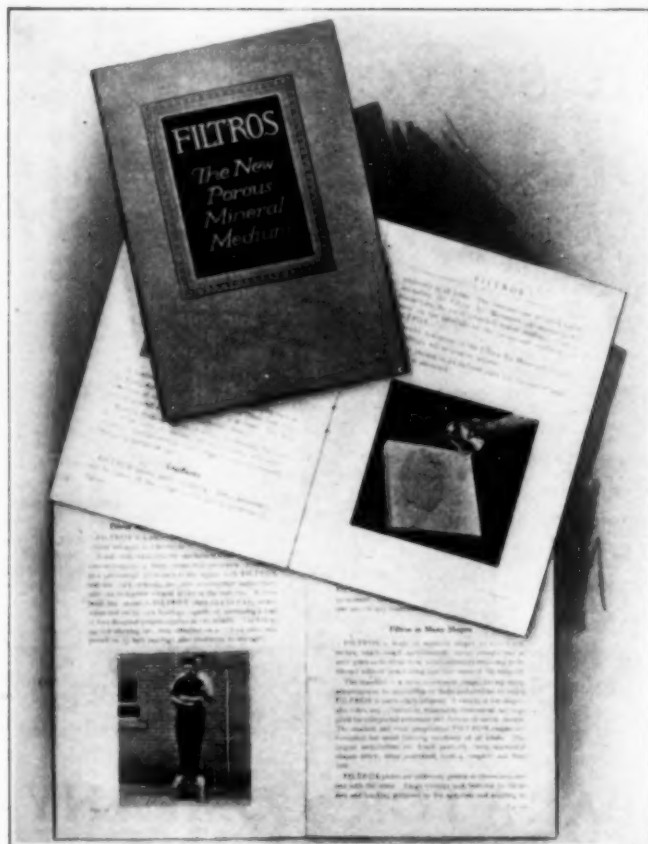


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Sperry Laboratory Presses save time and labor, and are most complete

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Why **FILTROS** installations are permanent and durable.

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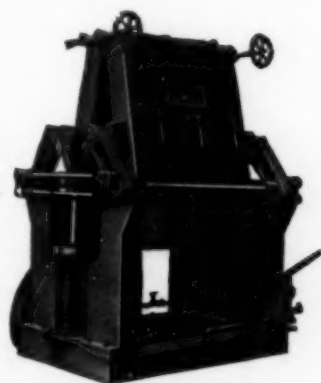
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The Worthington Filter Press squeezes the filtrate from the sticky or colloidal solutions and washes with steam, air, water or solvents, without cracking or channeling the cake.

Send your representative to see a press in operation on *your* material. We can test from five, to four hundred gallons in our testing press.

Write for a copy of Bulletin W-901-71

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New York Office: 115 Broadway

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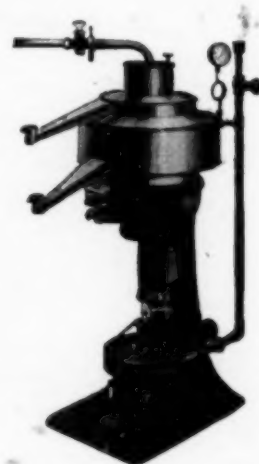
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Perhaps we can solve your filtering problem

We are daily applying our new Centrifugal Process to new uses—to the separation of oil and water, to the clarification of waxes, to the purification of edible oil, pharmaceuticals, extracts, etc.

We have solved the filtering and clarification problems for many concerns in varying lines of business. If you feel that your present filtering and clarification methods might be improved upon, giving you a better product at less cost for production, it won't cost you anything to submit your proposition to our engineers, and we will be glad to advise whether or not any of our machines are adapted to your individual requirements.

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This machine removes the finest flock and all suspended dirt as well as the coarsest sediment, from all varnishes, syrups, medicines, and pharmaceuticals.

It makes possible more perfect filtration at a lower cost.

Simple in operation and exceptionally durable. Made in four sizes.

Bulletin 102 tells about it.

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Hydro-Extractor

Tolhurst Centrifugals

are made in a wide variety of types and sizes, and have become the standard of efficiency and durability for all classes of chemical work.

They are unapproached for continuous and exacting service, and are the only scientifically self-balanced machines on the market.

Baskets of any practicable material; cases to suit any special requirements. Belt, engine or motor drive. Bottom discharge or removable baskets. Sizes from 12" to 72". We will make special types and sizes for any unusual service.

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Will Enable You to Save All Values Reduced to Solution and Recover the Solvent at Minimum Cost.

We are pioneers in the field—we developed the only really successful process, and we are still

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Cable: "Morefilter" New York

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Pratt Patent Rotrex Vacuum Pump

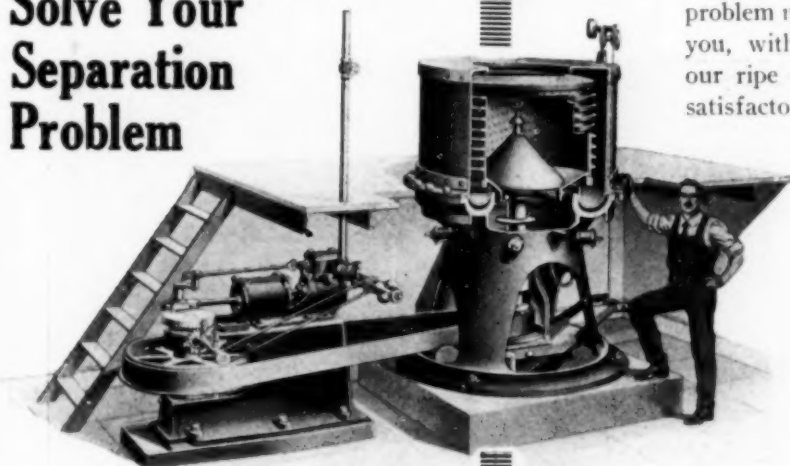
For use in connection with evaporators, dryers, vacuum pans, etc. Made in all sizes, for belt, motor or engine drive. This type has the advantage of being moderate in first cost, low in power consumption and absolutely reliable.

We also furnish complete steam condensing equipment.

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BRANCHES: New York, Boston, Chicago, Cleveland, Pittsburgh, Charlotte, N. C.; San Francisco.

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Whatever your extraction or separation problem may be, we shall be glad to give you, without obligation, the benefit of our ripe experience in finding the most satisfactory solution.

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HYDRO EXTRACTORS

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Centrifugal Pump & Machine Co.
PHILADELPHIA

Wash the Air While Drying It

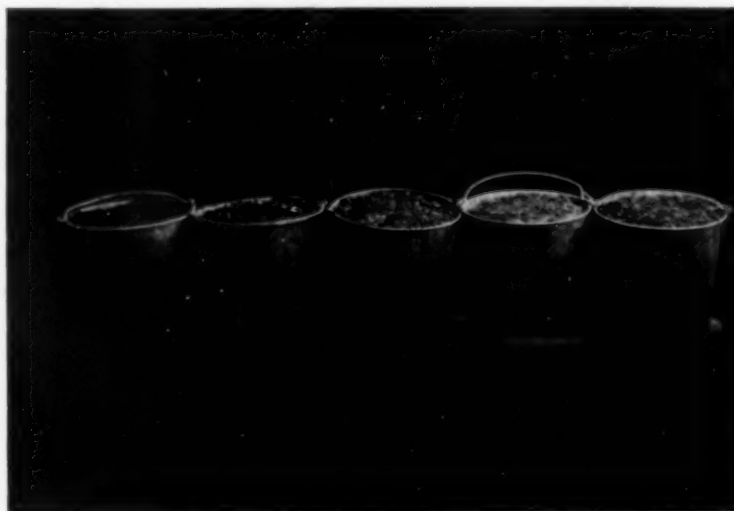
A system of water sprays thoroughly cleanses the air which passes through the

CARRIER Dehumidifier

The Carrier System of humidity reduction is based upon the control of the dewpoint. Sprays colder than the air produce condensation.

Carrier Apparatus is compact, automatic and economical.

Write for the booklet "CONDENSING MOISTURE FROM THE AIR."



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CARRIER AIR CONDITIONING CO.
OF AMERICA

Philadelphia,
Real Estate Trust
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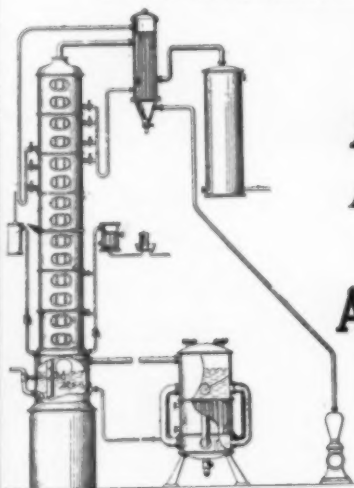
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Our Patent Continuous Acid still licensed, and producing wood alcohol from 1250 cords daily.

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Original "WESTON" TYPE

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**THE AMERICAN
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(INCORPORATED 1864)

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Standard for a Generation Swenson Evaporators

are found in every industry where evaporators are used. They have become so well and so favorably known that for most of these industries today the Swenson is standard. Repeat orders have followed one another, until now they form half of our business. At the same time, when required, we will design and construct evaporators of any type to suit special conditions, and of any materials, to handle any liquid.

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Of America**

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100% Relief All the Time

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Absolutely perfect circulation of the liquor in all cells; true film evaporation without complication; Condensation water available for preheated boiler feed; Instantaneous and continuous withdrawal without loss of heat, under absolute control all the time; No possibility for liquor to mix with condensation water at any time, either while in operation or at rest.—These are a few of the advantages of the Sanborn Evaporator.

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*are non-corrodible
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Acid proof stoneware of every commercial sort for industrial and laboratory uses will be found listed in the Chas. Graham Catalog. The making of special pieces is with us, such a commonplace that some customers consider us "Specialists on Specialties"—But whether your needs are every day or out of the ordinary, we want you to see for yourself what the quality of Chas. Graham Chemical Pottery amounts to in service.



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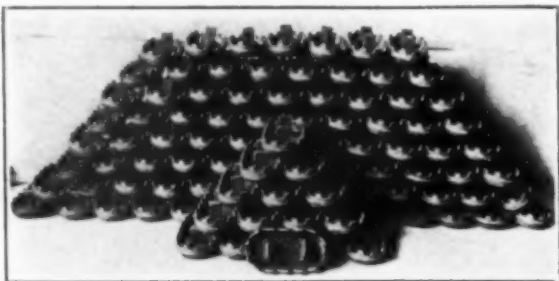
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Every piece clean cast, accurate, durable and like all cast silicon chemical ware highly resistant to chemical action—sulphuric, nitric and other acids have no appreciable effect upon this material—it is light in weight, strong, wonderfully durable.

Cast silicon chemical ware is made in pipe and fittings, cascade basins, nozzles, connecting pipes, manifolds, coolers, towers, etc.

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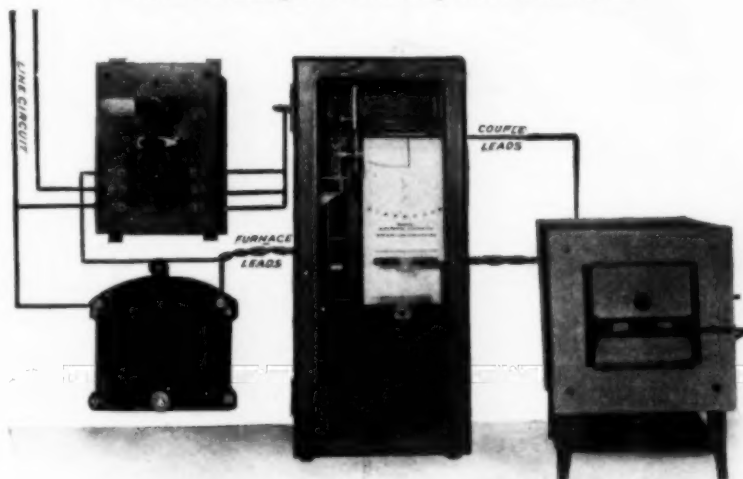
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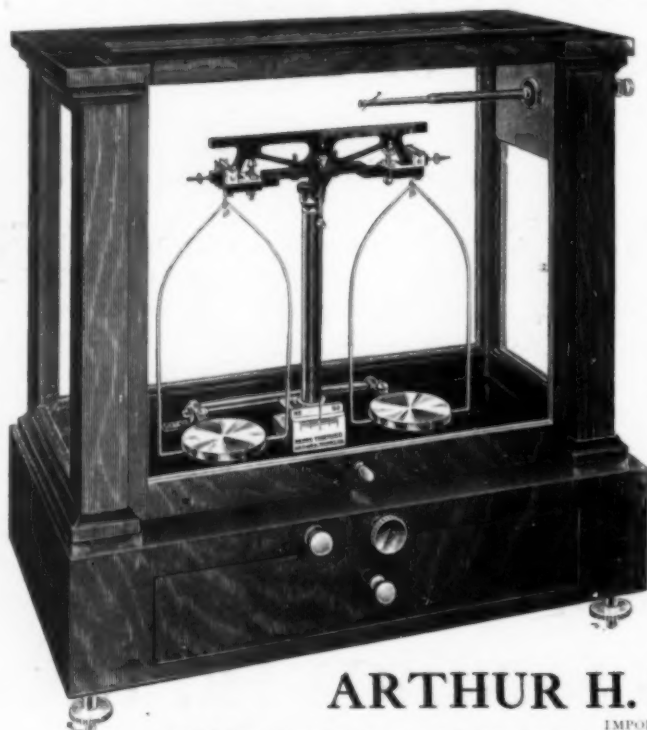
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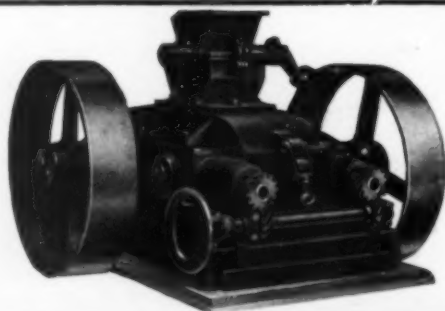
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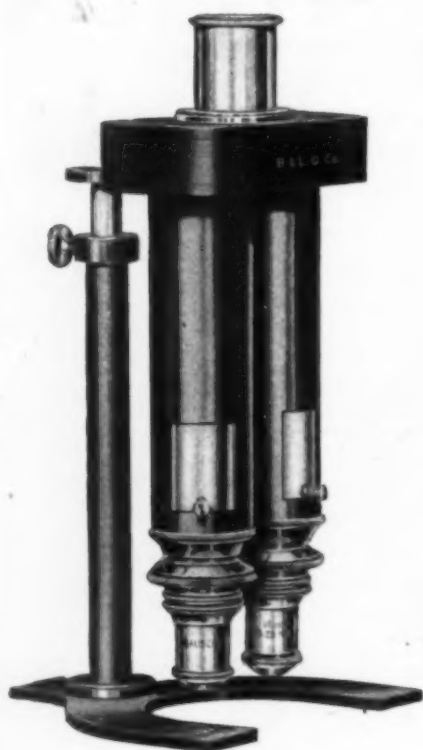
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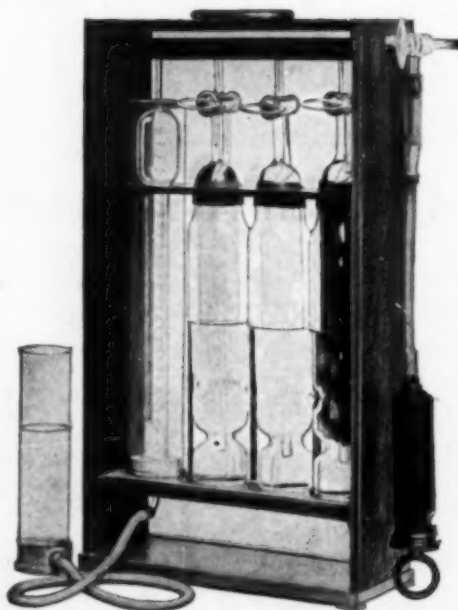
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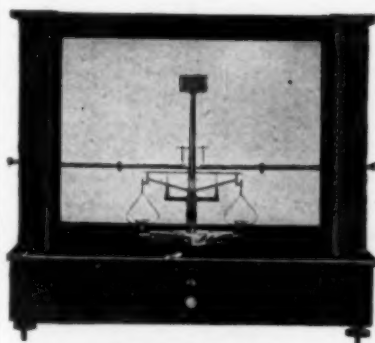
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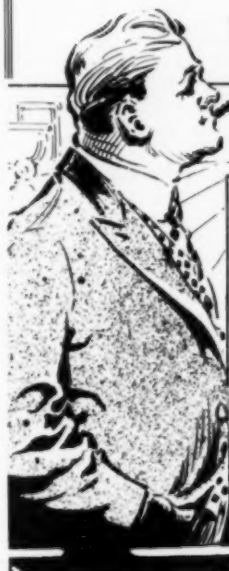
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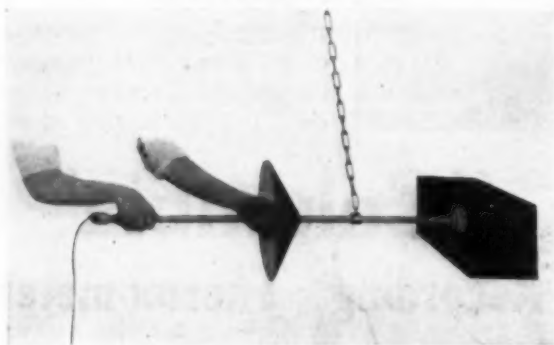
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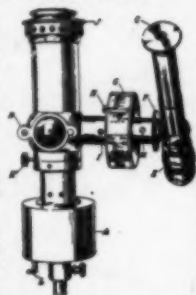
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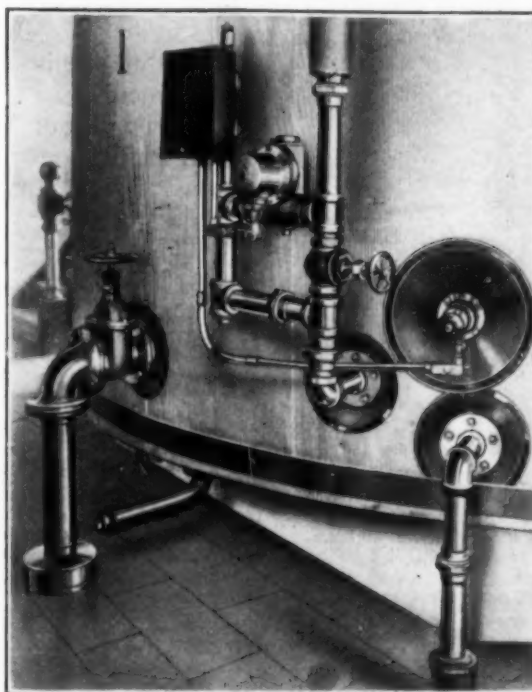
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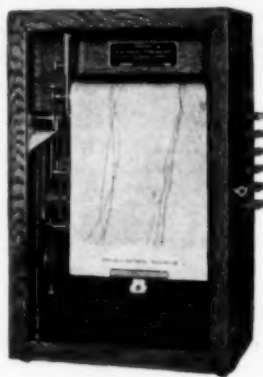
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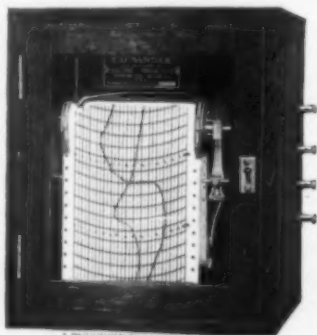
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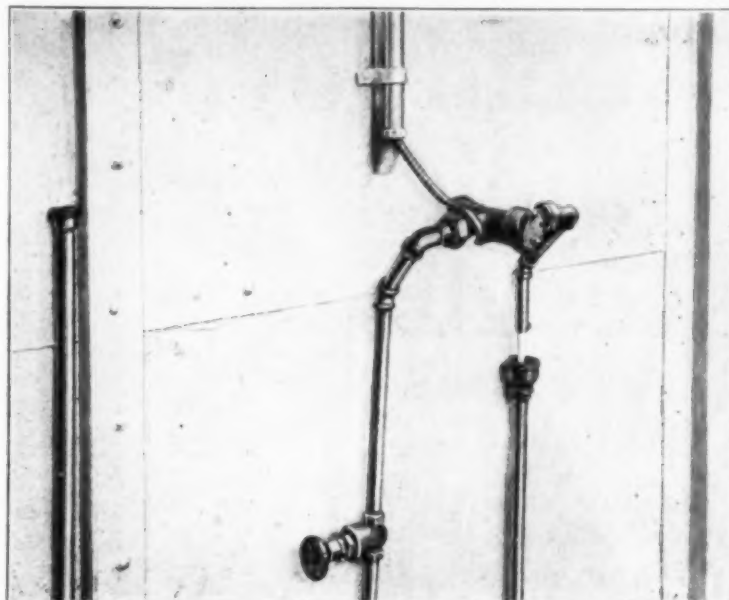
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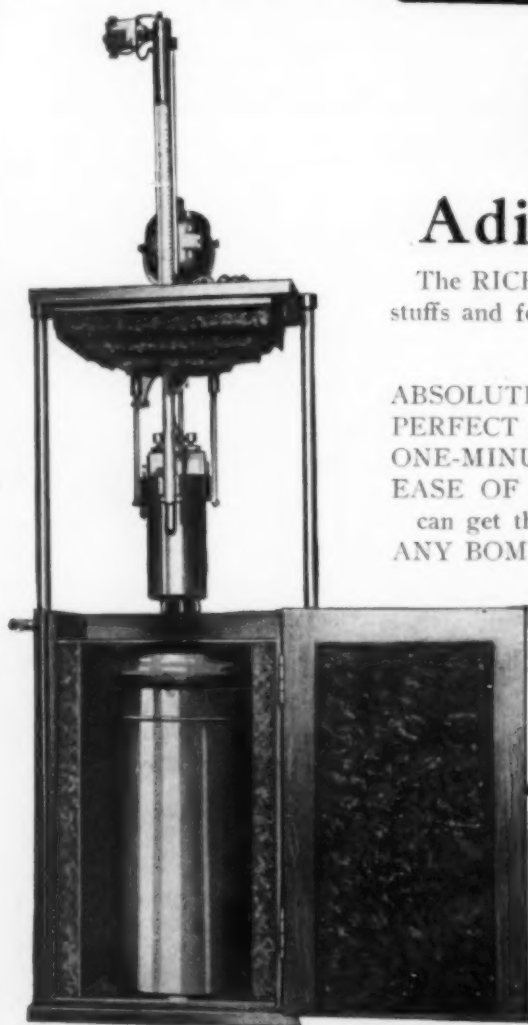
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Editor: Dr. E. F. Roeber, 29 Halsted Street, East Orange, N. J.

Business Manager: J. Malcolm Muir, 309 West 93d Street, New York City.

Publisher: McGraw Publishing Company, Inc., 239 West 39th Street, New York City.

Owner: McGraw Publishing Company, Inc., 239 West 39th Street, New York City.

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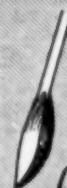
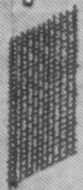
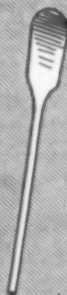
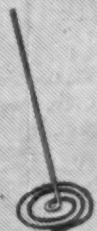
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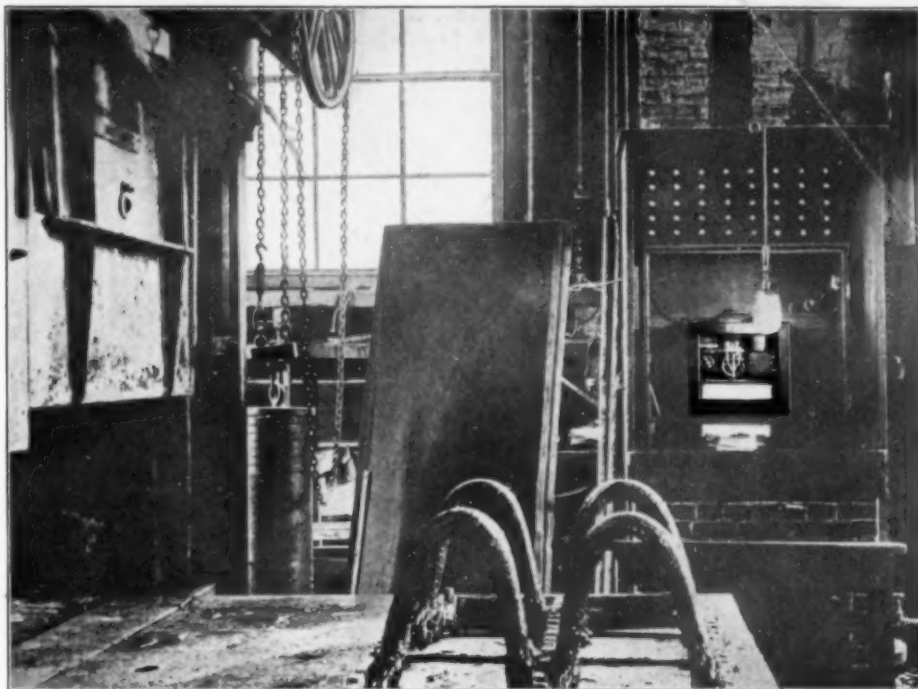
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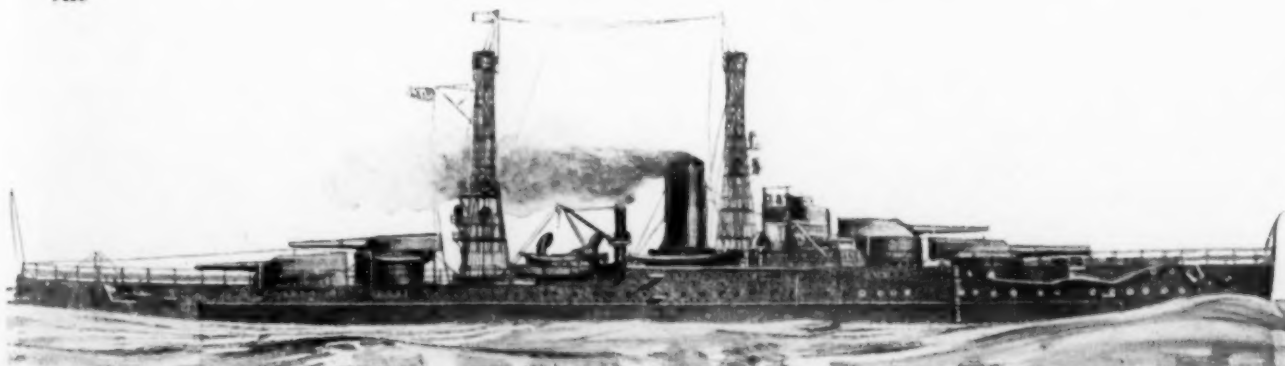
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